EVALUATING THE EFFICIENCY OF WAREHOUSE USING DATA ENVELOPMENT ANALYSIS (DEA)

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SUPERVISOR'S DECLARATION

I hereby declare that I have checked this thesis and in my opinion, this thesis is adequate in terms of scope and quality for the award of the degree in Bachelor of Industrial Technology Management (Hons).

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STUDENT'S DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged. The thesis has not been accepted for any degree and is not concurently submitted for award of other degree.

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This thesis is a symbol of appreciation for my most beloved mother, father and brothers.

DEDICATION

This Thesis is dedicated to my parents, project's supervisor, and friends who always support me for all these time during my research study till the end of the research.

First of all, I would like to dedicate this thesis to my parents who give me an encouragement and strength to finish my research project.

I would also like to dedicate this thesis to my late supervisor, Prof Razman bin Mat Tahar who gave me a lot of advices and suggestions throughout my study on this research. He always reminds me that the purpose of leaning and doing this thesis is not only for graduate from universiy, but it is just beginning point for my future. The example shown by him has also become a great help in the success of this thesis. Without his support and guidance this thesis will not be existed and presented. My deep condolence goes to his family.

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ABSTRACT

This study discusses about modeling the efficiency of the warehouse using Data Envelopment (DEA) method. The scope of this study is to focus on the evaluation performance efficiency value of warehouse. The time frame covered is one year which is in year 2014/2015. This study is conducted by using DEA software which we used CCR model to measure the efficiency of decision making units (DMUs) which we use the warehouse as the DMUs. It is a quantitative study which the performance efficiency of the warehouse is measured based on the variables of the input and output. The results of the CCR Model of the efficiency of the warehouse which is efficient was determined and use as the benchmark to the other warehouses. The improvement of the warehouse has been recommended by include as many DMUs as possible because with a larger population there is a greater probability of capturing high performance units that would improve discriminatory power.

Keywords: Data envelopment analysis, CCR model, warehouse, efficiency and slack

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LIST OF ABBREVIATIONS

DEA	Data Envelopment Analysis
AHP	Analytic Hierarchy Process
QFD	Quality Function Deployment
DMU	Decision Making Unit

CHAPTER 1

INTRODUCTION

This research study is to evaluate and analyze the warehouse performance from company of food manufacturing in Kuala Terengganu. The evaluation of the warehouse is to determine efficiency performance of the organization. The purpose of analyzing the performance of the warehouse is to improve the quality to become more efficient to support the market demand nowadays by using the data envelopment analysis technique which is commonly use in manufacturing and service sector. This chapter will cover the background of the study, problem background, problem statement, research objective, and research question, method of analysis, scope of study, significance of study, operational efficiency and conclusion of this chapter.

1.1 BACKGROUND OF STUDY

Our emphasis in this research is on basic DEA models for measuring the efficiency of decisions making (DMUs) when the process presented a structure of multiple inputs and outputs. The first DEA model, as this work originally presented by Charnes, Cooper, and Rhodes (CCR) in 1978. In this research, it more focus on labor performance in the food manufacturing industry. Since the labor cost is the largest cost component of general warehousing. In order to identify the best practice, a warehouse efficiency model is presented to evaluate the overall efficiency of warehouses at the enterprise level in the presence of multiple inputs and output which are involved.

It is developed by using Data Envelopment Analysis (DEA) as a multi-factor productivity model to measure the relative efficiencies of a homogenous set of Decision Making Units (DMUs). This research study used a set of warehouses where the relative efficiency score of each warehouse is calculated where multiple inputs and outputs are involved. The research begin with a general review background on efficiency and production measures, the DEA, CCR Model, warehousing, and basic terms or definitions.

The basic or unrestricted DEA model is applied to a group of homogenous warehouses which have similar inputs and outputs. Then, the model will be revised which is restricted DEA model with additional constraints is presented. Based on expert opinion in conjunction with strategic thinking, the model is revised with incorporates weight restrictions inputs from executives and decision makers who are in charge of setting the organization's goal and objectives. Besides, the primary objective of the restricted DEA model is to move from technical efficiency towards overall efficiency. The relative efficiency of the warehouses used in the study was analyzed before and after the use of weight restrictions.

1.2 PROBLEM BACKGROUND

The goal of this research is to evaluate the performance and efficiency using Data envelopment Analysis model that support the estimating of productivity and using it for quantitative benchmarking. This method quantifies the relative efficiency of observations of warehouse productivity performance.

Technical issues are addressed related to benchmarking best practice behavior in the warehouses. First performance needs to be measured in order to identify best practice among warehouses. There are a variety of tools can be used to measure the performance efficiency. One of the most common tools that we used is data envelopment analysis (DEA) which a system that consumes inputs to generate outputs.

The issues are to identify factors why the warehouse performance is not efficient in company where the analysis of warehouse performance data have been collected over a year using DEA method. This research is to identify causal factors which limit the

warehouse to perform efficiency and to identify the best opportunities to improve warehouse performance in a general warehouse setting. This method has been used for measure warehouse technical efficiency and for evaluating warehouse performance productivity. The two type of date have been collected which are inputs and outputs where this data are decision making unit (DMU). It is an interesting research question to see if the data warehouses in certain industries are a particular disadvantage to warehouse in other industries.

There are many factors that are believed to influence performance of the warehouse efficiency which they may use the unsuitable inputs for generate the output of the operation process. The outlier of efficiency of a set of data with high density can be avoid by using the rules of thumb on the number of inputs and outputs to select and their relation to the number of DMUs. The outlier in this research can be remove by follow the rules of thumb of DMUs.

1.3 PROBLEM STATEMENT

The measurement of efficiency in the warehouse operation and identification of sources of their inefficiency is a condition to improve the performance of the warehouse in a competitive environment. All inputs and outputs have an impact on efficient operation of such units, although some are considered more or less important. The lacks of data entries for any of the inputs in the warehouses will reduce the warehouse performance model are excluded.

In operation of warehouse, there are a lot of problems and constraints such as, machine failure, lack of labor at peak hour and etc which cannot be avoided. However, these problems can be reduced. The benchmarking practice behavior in the warehouses is related to the technical issues. The performance of the warehouse is reduced when the warehouses operation is inefficient.

The outlier can happen if the researches in the analysis have misreported data or are not measured correctly this must be avoided in DEA which is requires all observations be measured exactly. We shall not get into the inappropriate selection of data because certain characteristics of data that may not be acceptable for the execution

of DEA models. So, we must look at some data requirements and characteristics that may ease the execution of the models and the interpretation of results. The rule of thumb must also be followed to remove outlier from happen in this research.

1.4 RESEARCH OBJECTIVES

The objectives of this research are:

- ✓ To measure variables contributing the warehouse operation performance
- ✓ To evaluate the performance efficiency value of warehouse operation

1.5 RESEARCH QUESTIONS/HYPOTHESIS

The questions of this research are:

- ✓ What are the variables that contributing the warehouse operation performance?
- ✓ What are the performance efficiency values of warehouse operation?

1.6 METHOD OF ANALYSIS

Method, tool or technique is the important elements to conduct a research study. According to this research study the appropriate method to evaluate and analyze this research by using DEA method and data collection method. DEA is used widely used in application to measure efficiency and it was practiced in many countries. DEA software will be used to analyzed and quantified for every evaluated unit for the sources of inefficiency in the warehouse operation. It is also capable of handling multiple inputs and outputs and can being used with any inputs and outputs measurement. Besides, DEA is also proven to be useful in uncovering relationships that remain hidden for other methodologies. Moreover, DEA method no needs to explicitly specify a mathematical form for the production function. DEA software searches for the points with the lowest unit for any given output, then connecting those points to form the efficiency frontier. For any company not on the frontier is considered inefficient. There are many different

variables that could be used to establish the efficiency frontier such as number of labors, production units, service quality, and budget. This method is useful because it takes into considerations returns to scale in calculating efficiency which allowing for the concept of increasing and decreasing efficiency based on size and output levels.

Data collection method is very important because it can support the DEA method to evaluate and analyze the process. Real data is needed to create warehouse model using DEA software to represent the real warehouse performance efficiency. The data and information of the outputs and inputs must be true and accurate to make sure this research is benefits and useful to us. The better technique to collect the data and information is by using observation method which is called as primary data. Historical data and interview method as secondary data are also needed to support the primary data.

We will use DEA with the most basic being CCR based on Charnes, Cooper & Rhodes, although there are a many types of DEA. In this research, the CCR model is the most suitable to be use because it is basic model. We will collect data from the warehouse within one year of variables of inputs and outputs. The efficiency of the warehouse performance can be determined by using CCR model. The CCR is a method to investigate efficiency changes over multiple times periods. Besides, it allows an analyst to treat both nondiscretionary categorical inputs and outputs and to incorporate judgment. Meanwhile, CCR model defined efficiency as a ratio of weighted sum of outputs to a weighted sum of inputs, where the weights structure is calculated by means of mathematical programming.

1.7 SCOPE OF STUDY

This research will focus on evaluating the efficiency of warehouse of the food manufacturing industry in Kuala Terengganu. In this research, we will focus more on the performance efficiency of warehouse. With the DEA, we measure the efficiency of decision making units of the warehouse. The efficient warehouse will give more production and will give a good result in term of the profitability to the organization. In this research, we will use the CCR model which is in this method the data from the warehouse must be collect within one year of variables of inputs and outputs. The

efficient of the group of warehouses will be evaluated using DEA software and it will give a result for which one warehouse is the most efficient. Furthermore, we can know which warehouse is suitable to be used as the benchmark for best practice in the industry. From this research results, it may give a new idea and system to the organization to implement the new way to manage the organization to become more efficient.

At the beginning of the research, we will create a model based on the actual data that we get from group of warehouses of food manufacturing by using DEA software. Data envelopment Analysis (DEA) is a linear programming technique for measuring the relative efficiency of Decision Making Units (DMUs) with multiple inputs and outputs. It is used to establish a best practice group of efficient DMUs. By using the DEA software, we will run the model to get a result. From, the result, we will evaluate the warehouse of the food manufacturing and the efficiency of the warehouse can be determined. Based on the actual results, the evaluation of the performance will be a benchmark to the other model that will develop it to increase the performance for efficiency.

The two major aspects of DEA are inputs and output. In this research, we must consider the variables of the inputs and outputs to be used in DEA model. There are many types of inputs and outputs but we must make sure we make appropriate selection because there are certain characteristics of data that may not be suitable or acceptable to be used in this research. The types of inputs and outputs must contribute to the warehouse efficiency. So, we must focus more on the type of data and the numerical characteristics of the data. Joseph Sarkis. (2002). The inputs that we used in this research are number of labor, working hour, and cost while the output is sales.

1.8 SIGNIFICANCE OF STUDY

The efficiency of warehouse performance in the manufacturing is vital because without an efficient management, the company performance and reputation will decrease. This research is to overcome the problem of inefficient productivity in the warehouses operations. This automatically will give profitability and can practice the

best benchmarking in the warehouses. When the performance of the warehouse becomes more efficient, it can give profit to the company.

This research can be guideline to all the warehouse which want to improve the performance efficiency of the warehouse. Besides, this research result can also be used and apply for any food industry warehouse sector. This will provide strategy to the company on how to develop an efficient warehouse and can also overcome the low sales in the warehouse. So, the managers can reduce the cost of the warehouses to become more efficiency.

This study is important to the owner's of the warehouse, managers, and labors. Managers need to plan everything that related to the inputs to generate more outputs that are important to make sure the efficiency of the warehouse. Nowadays, there are a lot of techniques is upgraded to be more efficient. Thus, they need to study the new method or research to understand about the current problem that the others warehouse of the company face and see how they solve the problem by using certain technique, method and tools.

1.9 OPERATIONAL DEFINITION

Based on the research, there are several key terms have been used in this research study. For examples of key terms are warehouse, operational efficiency, efficient frontier, Data Envelopment Analysis (DEA), and efficiency. The definitions of all the key terms are:

Efficiency:

Efficiency is defined as the ratio of outputs to inputs. It is a measure of performance relative to some reference value. The difference between efficiency and productivity is that productivity for an individual DMU can be calculated without reference to any DMUs, while efficiency is a ratio of productivities with reference to an efficient frontier. It is important to identify the observational unit in any efficiency study. In this study, the observational unit is the data warehouse.

Efficient frontier:

An efficient frontier is defined as a description of the correspondence between input and output bundles when a DMU is operating at the best case productivity level.

Warehouse:

A warehouse is a commercial building for storage of goods. Warehouses are used by manufacturers, importers, exporters, wholesalers, transport businesses, customs, and etc. They are usually large plain buildings in industrial areas of cities, towns and villages.

Data Envelopment Analysis (DEA):

Data Envelopment Analysis is a method use to measure productive efficiency of decision making units (DMUs). It is a method that usually used in economic and is also used for benchmarking in operations management. A set of measures is selected to benchmark the performance of manufacturing and service operations. According to the Sherman and Zhu (2013), DEA is referred as balanced benchmarking.

Operational efficiency:

Operational efficiency is defined as the ratio between the input to run the operation and the output gained from the operation. The output to input ratio will improve when we improving operational efficiency. Both the input and the output site should be measured to know the operational efficiency.

1.10 CONCLUSION

The focus of this chapter is on efficiency measurement of the warehouse by using DEA models. The DEA gives us a tool to estimate relative efficiency of a selective entity in a given group of units and criteria. The efficiency in a warehouse performance needs to be measured by all the warehouse's owner or managers. This is because an inefficient of warehouse will affect the warehouse production, profitability and reputation. The two type of date have been collected which are inputs and outputs where this data are the important data element of decision making unit (DMU). The selection of the inputs and outputs is based on the significance of the inputs and it is critical to select the most representative and meaningful inputs and outputs. This is because DMUs efficiency is driven by its inputs and outputs, since the primary objective of DEA is to make an overall assessment of the efficiency of DMUs. The issues are to measure variables of DMUs contributing the warehouse performance and why the warehouse performance is not efficient where the analysis of warehouse performance data have been collected within a year using DEA method. The benchmarking practice behavior in the warehouses is related to the technical issues. The performance of the warehouse is reduced when the warehouses is inefficient. To overcome of this problem, DEA method is the most suitable approach to be used because DEA model can measure the efficiency of each warehouse. This method has been used for measure warehouse technical efficiency and for evaluating warehouse performance. When the model was created, we can see the results of performance efficiency of the real warehouse. This is advantage to manager because they can reduce the cost in the warehouse. So, the profit of the warehouse's company will increase when they know how to manage the warehouse efficiently. In this study, the basic DEA method which is CCR model will be used to measure the efficiency of the warehouse.

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

Literature review is a study on the literature that has been published by the researcher and scholars. The types of literature review include journal, articles, book, database and primary source. Newspapers, magazines, films, video, audio and secondary data are also included in the literature review but not widely used by the researcher. The primary source is always used by the research to refer and support the research as the evidence which is original information. This chapter will gives some historical background about the DEA methods used in efficiency analysis of warehouse. The literature review will be divided into several subtopics which include measuring performance in the warehouse, overview of DEA, data requirement research, and operational efficiency.

2.2 MEASURING PERFORMANCE IN THE WAREHOUSE

A warehouse or distribution center is a location, which is a large building and using specialized equipment to store goods temporarily, in the process of supplying those good to customers or other members of a supply chain. Warehouses are not all alike, and various subgroups can be identified where the inputs, outputs and attributes

may be different for each industry. For example, warehouses can be grouped by industry such as automotive, electronics, pharmaceuticals, and etc.

The most appropriate production function model is important to be select wisely for the group being studied. Although information can be used about the industry to identify the model, it can also be possible to identify observations from the subgroup which are not consistent with the model and the group of warehouses identified for analysis. The data those are inconsistent with the other data from the observations for this process it is referred as outlier detection. An analyst can correct and identify data entry errors or observations that do not belong to the group from the results of an outlier detection method. Thus, a warehouse can be compared to a group of warehouses where to it is truly similar and benchmarking can be makes so that a best practice results more accurate.

In order to measure the performance of the warehouses, the inputs consumed and the outputs generated need to be identified and quantified. There is reason to believe the sample is representative of the population is reasonably accurate when the number of warehouses being analyzed is large. However, it is more difficult to identify for the entire group in a smaller data sets which is largely unobserved. The performance of the observed warehouses still can be identified from a set of a relative efficiency estimates. It is suffice to estimate relative efficiency when the data set is small. Furthermore, there are many factors not under the control that affect efficiency of the warehouse. For examples such as market conditions, weather, and other companies competitive behavior. The warehouse management cannot control of these variables for either short-term or long-term decision making. There are a lot of challenge in measuring warehouse efficiency such as to identify the inputs, outputs and attributes that most influence the warehouse's efficiency (Johnson 2006).

2.3 OVERVIEW OF DATA ENVELOPMENT ANALYSIS (DEA)

DEA was first introduced by Charnes, Cooper and Rhodes (1979) which is linear programming technique to determine efficiency. This technique of CCR always used in a field of analysis for the economic analysis. A measure of the ratio of weighted outputs over inputs is calculated for each DMU. A DEA efficiency is calculate by

compared of the estimate two distances. A technically efficient producer can produced the same output with less input or used the same inputs to produced more of output. Efficiency of DEA is calculated as the ratio of the distance to the frontier divided by the distance to the point where efficiency is measured. In this way of efficiency measured, input oriented DEA always will gives efficiency estimates less than or equal to 1, where output DEA will gives efficiency estimates greater than or equal 1.

Besides, the efficiency in a cost context was introduced by Farrell to concept of production efficiency. While Debreu also contributed to this field in Debreu (1951) which defined a coefficient of resource utilization as ratio between minimized resource costs obtain in a given consumption bundle and actual costs. Proportional contraction of resources also measured by him. Farrell sited Debreu for his coefficient as an inspiration for the concept of technical efficiency but the concept of Debreu should be noted that Debreu's concept was strictly build from resource cost side analysis.

Farrell (1957) was introduced the path breaking paper which introduced the field of non-parametric efficiency. This contribution can be summarized as three fold:

- ✓ An efficiency measure is based on contraction or expansion from inefficient observations to frontier.
- ✓ A production frontier is specified as the most pessimistic linear envelopment of data,
- ✓ Newly defined frontier is calculated by solving system of linear equations, obeying the conditions of the unit that its slope is not positive and no observed point is lies between it and origin.

Farrell efficiency measure further divide into technical efficiency and price efficiency. CCR identified the connection between variables indices, where tried to find weight sums of inputs and outputs and the Farrell technically efficiency measure. Farrell description of his technique was simple and intended to be easily understand, CCR added the mathematical rigor allowing DEA to be valuable research tool it is today. Furthermore, the CCR assumed constant return to scale (CRS) and it is will be referred to as the constant return to scale DEA (CRS-DEA) model.

Six consistency conditions any method of efficiency evaluation should need were introduced by Bauer et al. (1998). There are:

- ✓ The different approach of estimates efficiency should have comparable means, standard deviations, and other distributional properties.
- ✓ The DMUs should be rank by the different approach in approximately the same order.
- ✓ The most same institutions should be identifying by the different approach as the best practice and as worst practice.
- ✓ The useful approaches should demonstrate reasonable stability over time. For example tend to identify as relatively efficient or inefficient with consistent in different years.
- ✓ The different approaches of estimates efficiency should be reasonably consistent with the competitive conditions in the market.
- ✓ All the useful approach to measured efficiency should be reasonably consistent with standard non-frontier performance measures. For examples such as return assets or revenue cost.

There are a lot of advantages of using DEA which is it can handle multiple input and multiple output models. DEA can identify the possible peers as role models who have an efficiency score of 1and sets improvement targets for them. By providing improvement targets DEA acts as an important tool for benchmarking. Besides, the possible sources of inefficiency can be determined by using DEA method.

2.4 DATA REQUIREMENT RESEARCH

There are typically three variables are used in describing a data set to be used in DEA which are number of inputs, number of outputs, and number of data points or Decision Making Units (DMUs) . It is important to understand the relationship between these variables. Generally, we would expect to achieve a valid result, larger model specifications would need larger data sets to increase the dimensionality and complexity of the production frontier. One of the difficulties in developing production model is in preparation of the data. The discrimination exists between efficient and inefficient unit

is determined by the choice for the number of inputs and outputs, and the DMUs. When evaluating the size of data set, there are two conflicting considerations. The consideration is to achieve greater probability of capturing high performance units which is by included as many DMUs as possible that is in larger population that would determine the efficient and improve discriminatory power. The assessment of operational efficiency using DEA begins with the selection of appropriate input and output measures (Fang 2010).

While the other consideration is that with a large data set the homogeneity of the data set may decrease. Furthermore, larger data sets also tend to increase the computational requirements. Some rules have established to select number of inputs and outputs and their relation to the number of DMU that is rules of thumb. The lower bound on the number of DMUs should be the multiple of the number inputs and outputs to get good discriminatory power out of the CCR model. This is because the issue that there is flexibility in the selection to assign input and output values to determine the efficiency of each DMU. To attempting DMU to be efficient by assign all its weight by single input or output. For example, if there are 2 inputs and 4 outputs the minimum total number of DMUs should be 8 for some discriminatory power to exist. Besides, Golony and Roll (1989) introduce a rule of thumb that the number of units should be at least twice the number of inputs and outputs. This rule is to make sure the basic productivity models are more discriminatory (Sarkish 2002).A general rule is using three DMUs for input and output variables used in the model in order to insure sufficient degrees of freedoms for a meaningful analysis.

2.5 OPERATIONAL EFFICIENCY

Operational efficiency is about the ratio between the outputs to inputs. Generally, company management is measure on the input side. For example the unit production cost, number of labor, number of supplier, labor working hour, and etc. A company should define and measure on both input and output side when measuring operational efficiency. Moreover, benchmarking is very important to define measure and track performance indicator for load and complexity as well when to compare numbers with others. Operational efficiency has been a common topic in the

information technology literature with the focus on the firm level using secondary data (Michael Mannino 2008).

CHAPTER 3

RESEARCH METHODOLOGY

3.1 INTRODUCTION

In this research, a research methodology can be explained as a method and technique on how to conducting research to answer the research question and solved research problem under the study. This chapter will include the research design, data collection method, and DEA model. The warehouse efficiency is presented using Data Envelopment Analysis (DEA) model to measure the relative efficiency of Decision Making Units (DMU), which are represent by multiple inputs and outputs.

3.2 RESEARCH DESIGN

The research starts with a general review and background on warehouse, the DEA model basic definitions and productivity measures. Research design is a process to make a framework and planning to conduct the research from the beginning steps of the research until the end in detailed. Besides, it will elaborate more on the research framework or design, how to collect the data, and how the data will be analyzed to get the results. Research design can be figure out the overall of the research where the step

to make sure the planning of the research process must be consider seriously so the research flow is going smoothly as expected. Furthermore, it is also able to see what is the problem that may occur when to conduct a research and able to control the variance during the research. Research design can also be able to answer the research question.

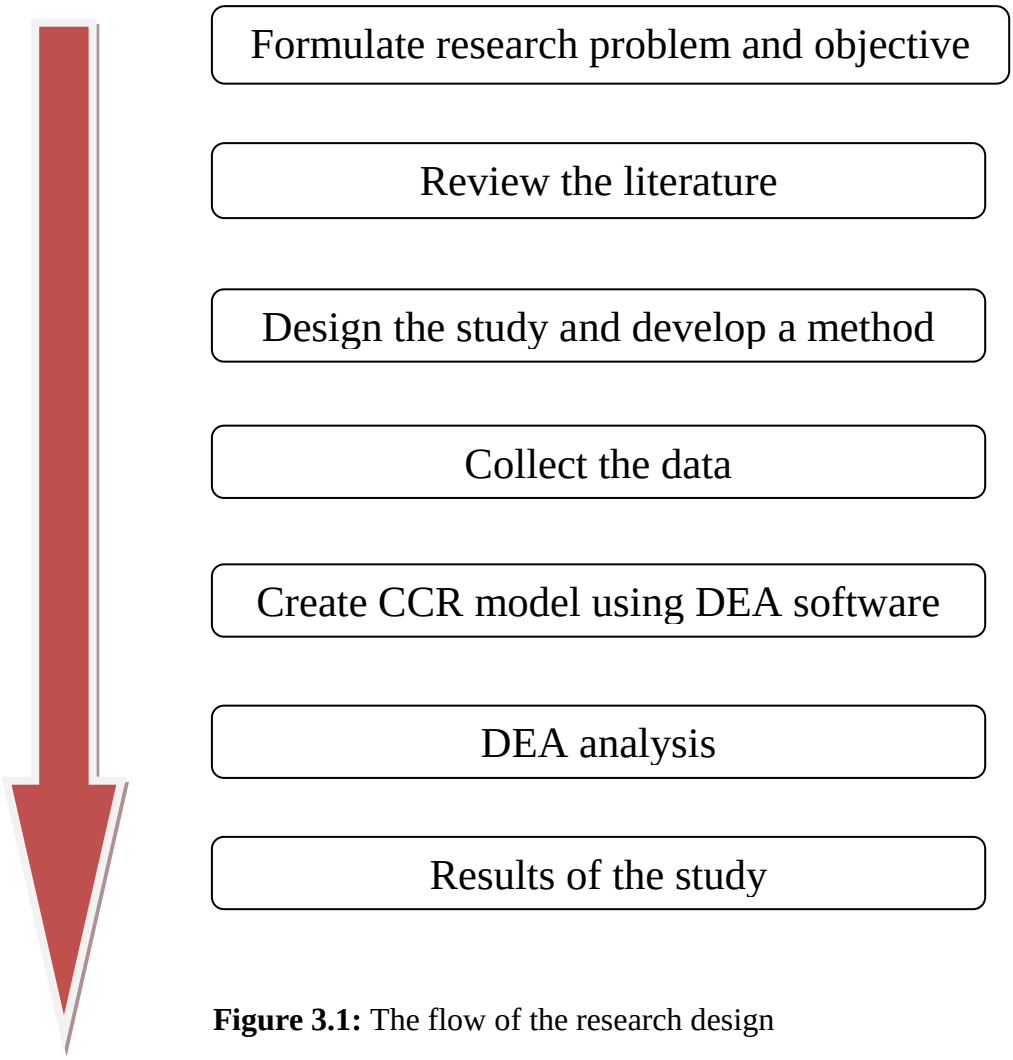

Figure 3.1: The flow of the research design

Step 1: Formulate the research problem and research objective

For the first step of the research on warehouse performance efficiency is defining on what is the problem that warehouse organization was faced which affect the efficiency and production of the warehouses. From the problem that occurs in the warehouse organization, research objective can be developing in the research design.

Research objective is a purpose of doing the research and to solve the organization problem.

Step 2: 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 cannot support the current situation since the technology nowadays changes are very fast.

Step 3: Design the study and develop a method

After reviewing the literature, the research will be more easier because understand overall of the problem and the objective of the research. When understand what need to do on the research, the design of the study is making and the method is decide which is suitable and appropriate to use to develop and conduct the analysis. It is very important to choose the suitable method in the research study because the mistakes of choosing the wrong method maybe cannot give the most accuracy answer to the research objective. The study may become a not good research h and will not give benefit to be study by others. The most suitable method for this research is constraint return CCR method.

Step 4: Collect the data

From this research study, data collection is needed to proceed with the research. This is because the data give the true and valid information that can be use to evaluate and analyze the performance efficiency of the warehouse. Data collection is the most important because it is the key for every research. The type of data is referring method and how to run the method. For DEA method, the decision making units (DMUs) are really important to get the right inputs and outputs. The inputs consist of number of labor, working hour, cost and where the output consists of profit or sales. The inputs and outputs must be logic which whether it affect the performance efficiency rate or not.

The not suitable data and information will be useless result which is not accurate and this study will be useless because not give benefits to the organization.

Step 5: Create CCR model using DEA software

When get all the data and the information, the data of the inputs and outputs can be put into the DEA software to create a model. Choosing the correct method in the DEA software is important which we choose the CCR method which can estimate the efficiency within a year. Thus, we can get the right result for the efficiency of the warehouse in the organization.

Step 6: DEA analysis

DEA analysis is an analysis to evaluate and analyze the model to be more efficient and identify factors contributing to the warehouse system. After using the DEA efficiency model and get the result analysis, we were able to interpret the result and determine the efficiency of the warehouse and debates around specific warehousing issues.

Step 7: Result of the study

After the DEA analysis, the result of all model that created using the CCR method need to measure its performance. From the result, we will get efficiency performance of the warehouse that gives the high efficiency to the efficiency of the warehouse that will be chosen.

3.3 DATA COLLECTION METHOD

Data collection method is a very important aspect during doing a research. This method involved the gathering and measuring the information process. The research study will not achieve the research objective without the relevant and accurate data and information. Data collection of the inputs and outputs or results that we get can be use to answer the research questions and hypothesis. The data must be evaluated before implementing it. Data can be divided into two categories which is quantitative and qualitative. However, in this research we used a quantitative data which was obtained

from company by sending a form to be filled by the individual in the warehouse organization.

The accuracy of the data collection is very importance to capture the quality of evidence that can be translating into rich data analysis which can be use to answer the research questions. It is significant to maintain data integrity and accuracy which can support the detection of errors in the data collection process. Based on this research study, we use DEA method to collect the data of inputs and outputs for primary data. For secondary data, historical data is needed to support the primary data such as articles, journal, books and documents for generate idea to completing this research study.

3.4 CCR MODEL USING DEA SOFTWARE

Data Envelopment Analysis (DEA) is a method in operation research for the estimation of production frontier which is used to measure efficiency of decision making units (DMUs). According to the research, the DEA are heavily dependent on the data set that is used as an input to the productivity model. There is very important to select the suitable input and output which affect the efficiency of the warehouse. This will prevent the appropriate selection which may lead to get not accuracy result of the research.

Firstly, we must prepare the data for DEA. We must make the appropriate selection for input and output data to get the accuracy of the research. Generally, the performance efficiency warehouse can be measure by select the suitable inputs and outputs because DMUs determine how good discrimination exists between efficient and inefficient units. There are certain characteristics of data that may not be acceptable for the execution of DEA models.

Many DMUs is possible to include because with a larger population there is a greater probability of capturing high performance unit that would determine the efficient frontier and can avoid discriminatory power. The DMUs should be multiple of the number of inputs and the number of outputs to get good discriminatory power out of

the CCR model. There is flexibility in the selection of weight to assign to input and output values in determining the efficiency of each DMU. For example, if there are 2 inputs and 4 outputs the minimum total number of DMUs should be 8 for some discriminatory power to exist in this model.

Golany and Roll (1989) introduced the rule of thumb that the number of units should be at least twice the number of inputs and outputs. Dayson et al. (2001) mentions a total of two times the product of the number of input and output variables. For examples, if there are 3 input and 4 output, model Golany and Roll recommends using 14 while Dayson et al. recommends 24. These numbers should probably be used as minimums requirement for the basic production model.

The CCR model was initially proposed by Charles, Cooper and Rhodes in1978 which is the one of the most basic model. CCR model allow an analyst to treat both nondiscretionary and categorical inputs and outputs and to incorporate judgment. They easily investigate efficiency changes over multiple time periods.

For each DMU, there are virtual input and output by weights (v_i) d (u_r):

$$\text{Virtual input} = v_1x_{1o} + \ldots + v_mx_{mo}$$
$$\text{Virtual output} = u_1y_{1o} + \ldots + u_sy_{so}$$

To determine the weight, we use a linear programming to minimize the ratio;

$$\frac{\text{Virtual output}}{\text{Virtual input}}$$

Then, the weights in DEA are derived from the data because optimal weights may vary from one DMU to another DMU. For each DMU is assigned to a best set of weights with values.

Let the output and input of DMU_jbe{ $x_{1j}, x_{2j},\ldots x_{mj}$ } and {$y_{1j},y_{2j},\ldots, y_{sj}$ }. The input and output data matrix x and matrix y are arranged as follows, where X is [m x n] and Y is [s x n], as below:

$$x_{31}\ x_{32}\ \ x_{33}\qquad X = \begin{pmatrix} x_{11} & x_{12} & x_{13} \\ x_{21} & x_{22} & x_{23} \end{pmatrix}$$

$$y_{31}\ \ y_{32}\ \ y_{33}\qquad Y = \begin{pmatrix} y_{11} & y_{12} & y_{13} \\ y_{21} & y_{22} & y_{23} \end{pmatrix}$$

Based on the data, we measure the efficiency of each DMU once and need n optimization, one for each DMUj to be evaluated. For example, let the $DMU_j$to be evaluated on any trial and be designated as $DMU_o$where o ranges over 1,2,3,….n. Then, we solve the following fractional programming problem to obtain values for the input as "weight" (v_i) (i = 1,…,m) and the output "weights" (u_r) (r = 1,…,s) as the variables. While, (FP_o) is fractional program.

$$(FP_o)\qquad \max_{v,u}\ \theta = \frac{u_1y_{1o} + u_2y_{2o} + \cdots + u_sy_{so}}{v_1x_{1o} + v_2x_{2o} + \cdots + v_mx_{mo}}$$

$$\text{subject to}\quad \frac{u_1y_{1j} + \cdots + u_sy_{sj}}{v_1x_{1j} + \cdots + v_mx_{mj}} \le 1\ \ (j = 1,\ldots,n)$$

$$v_1, v_2, \ldots, v_m \ge 0$$

$$u_1, u_2, \ldots, u_s \ge 0.$$

Then, we replace the fractional program (FP_o) to a linear program (LP_o). The fractional program (FP_o) is equivalent to linear program (LP_o).

From a fractional to linear program:

$$(LP_o) \qquad \max_{\mu,\nu} \theta = \mu_1 y_{1o} + \cdots + \mu_s y_{so}$$

$$\begin{aligned} \text{subject to} \quad & \nu_1 x_{1o} + \cdots + \nu_m x_{mo} = 1 \\ & \mu_1 y_{1j} + \cdots + \mu_s y_{sj} \le \nu_1 x_{1j} + \cdots + \nu_m x_{mj} \\ & \qquad\qquad (j = 1, \ldots, n) \\ & \nu_1, \nu_2, \ldots, \nu_m \ge 0 \\ & \mu_1, \mu_2, \ldots, \mu_s \ge 0. \end{aligned}$$

Meaning of optimal weights:

The (v^*,u^*) obtained as optimal solution for (LP_o) results in a set of optimal weights of DMU_o. The ratio scale is:

$$\theta^* = \frac{\sum_{r=1}^{s} u_r^* y_{ro}}{\sum_{i=1}^{m} v_i^* x_{io}}.$$

$$\theta^* = \sum_{r=1}^{s} u_r^* y_{ro}.$$

(v^*,u^*) is the most favorable weights for the DMU_o to maximizing the ratio scale. The constraints mean the ratio of virtual output vs virtual input should not exceed 1 for every DMU. The CCR model objective is to obtain weights (v_i) and (u_r) which maximize the ratio of DMU to be evaluated. We assuming that all outputs and inputs have some nonzero worth to be reflected in the weights u_r and v_i being assigned some positive value.

CHAPTER 4

MODEL DEVELOPMENT AND DATA ANALYSIS

4.1 INTRODUCTION

The purpose in this chapter is to evaluate efficiency of warehouse performance using DEA method. There will be described more detailed about the model development which is creating by using the DEA software to measure the efficiency of multiple decision units (DMUs) which the production process presents a multiple inputs and outputs. Besides, this chapter also will explain and discuss about the results that getting by the DEA software using CCR model and compare the results which is more efficient between the decision making units of warehouse. So the data analysis is very important to know the most efficient of DMUs in the DEA software. For this study, the data was collected at the warehouse of Ziq Bakery, Sweeden Bakery and Abdullah Bakery in Kuala Terengganu.

In this chapter, the model will be developed in the DEA software and make an evaluation of the data collected. From this analysis, the efficiency of the warehouse will determine. The production performance will be increased by modifying some variables by adding or decreasing the number of input to improve performance of the warehouse.

4.2 MODEL DEVELOPMENT AND DATA ANALYSIS

4.2.1 Model Development

The model of the processes was developed by using the DEA software which evaluates the efficiency of the warehouse of Ziq Bakery, Sweeden Bakery, and Abdullah Bakery. The model was constructed by using model DEA selection of CCR model. There are several variables of inputs and outputs were choosing to develop a model. For an inputs which are number of labors, working hour and cost while for the output which is sales.

First of all, the data that taken from the company must be put in the excel sheet before be selected to be run in the DEA software. The choosing of the suitable inputs of data is very important because it affect the outputs. The data must be accuracy to capture the quality of the evidence which can be use to answer the research question and significant for the result.

This study was using DEA Solver Training Version software to interpret the data. Since the DEA is a powerful method which is most suitable to be used to measure the efficiency of the DMUs. The understanding and interpreting of this software is very important because it may causes the data cannot run or did not get the expected result.

Figure 4.1: Learning Version for DEA Solver

Model selection is the crucial step because the selection of the correct model will affect the result. There are several options which model option to use such as CCR, BCC, RTS and window analysis. In the research, the CCR model is select to measure the efficiency of DMUs of warehouse. Then CCR-I must be choose before proceed with the next step. Choosing the correct method in the DEA software is important which we choose the CCR method which can estimate the efficiency over a year. Thus, we can get the right result for the efficiency of the warehouse in the organization.

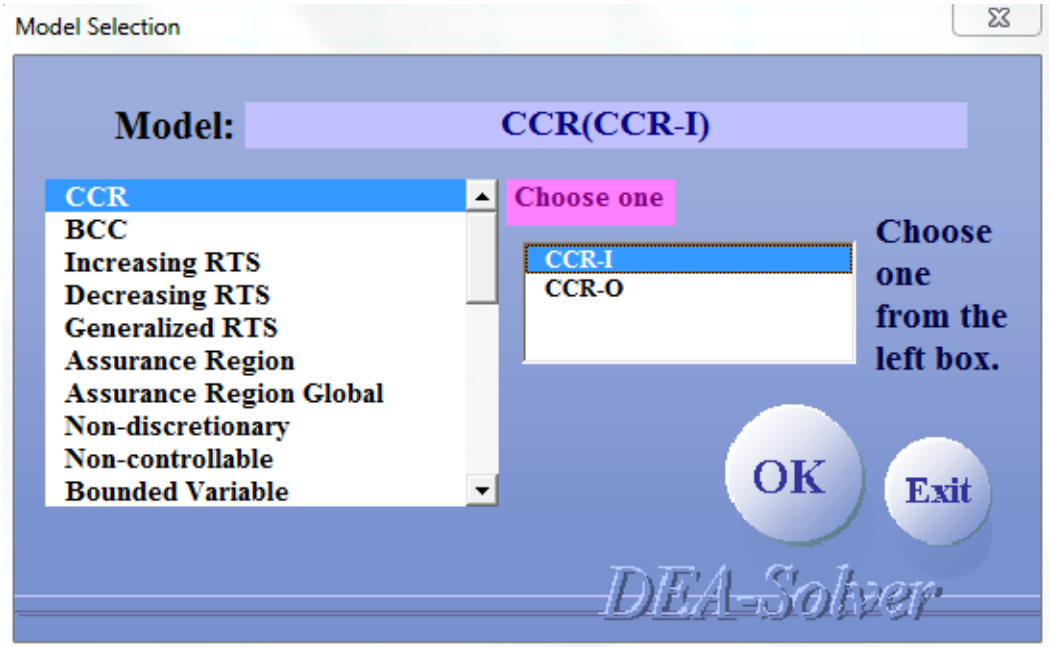

Figure 4.2: Selection of CCR Model

When get all the data and the information, the data of the inputs and outputs can be put into the DEA software to create a model. The CCR-I model will proceed with the data for selection which the data was already was saving in Excel sheet before.

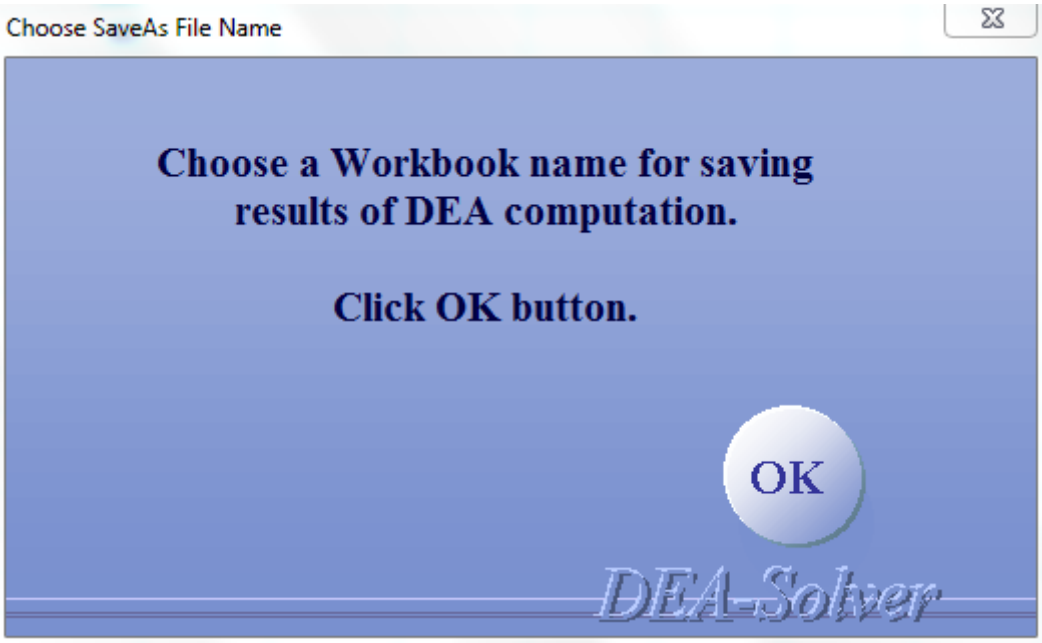

Figure 4.3: Choose a Workbook name

The DEA Model which is CCR-I was run to get the result for which warehouse that is most efficient and suitable to be the benchmark to other warehouse.

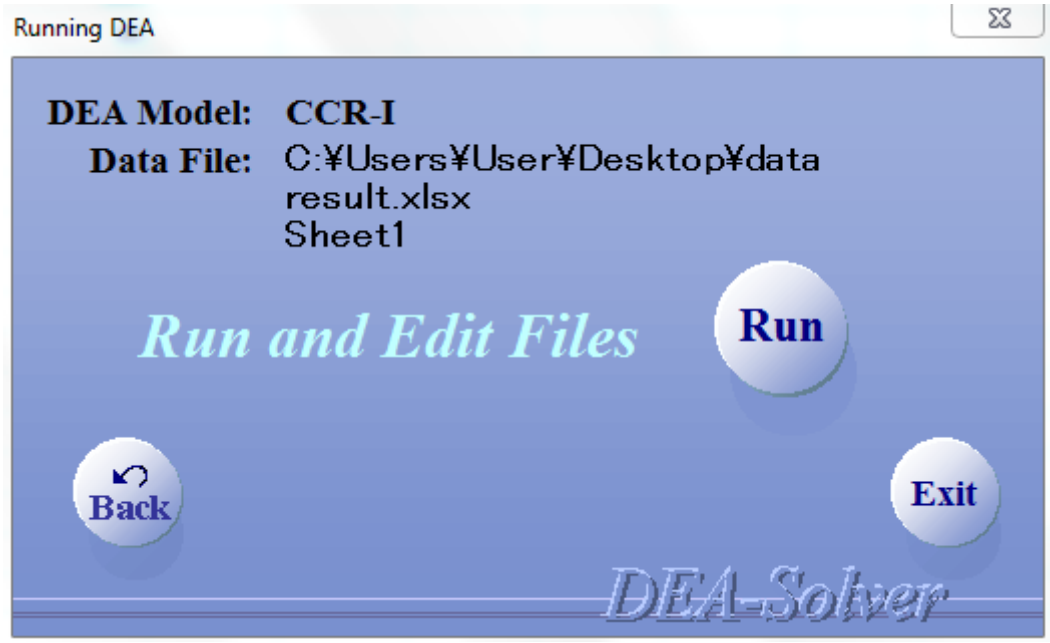

Figure 4.4: Run the DEA

4.2.2 Data Findings

The data and information was taken from warehouse of Ziq Bakery, Abdullah Bakery and Sweeden Bakery in Kuala Terengganu. The data and information was obtained will be analyze by using the Input of CCR-I in the DEA Software. The function of the CCR model is to estimate the efficiency of the DMUs over a year.

From the information in the company, the data about number of employer, working hour, cost and sales of three warehouses were obtained. The DMUs consist of three warehouses while the variables are three for inputs and one for output. According the guideline for using the DEA Solver the data and information that was obtained were save in the Excel sheet in the right format before key it in onto the CCR model. Table 4.1 below show what data that was collected and it is put in the standard format so it can be run in the DEA software.

Table 4.1: Data Findings

	(I)No of employee	(I)Working Hour	(I)Cost	(O)Sales
Abdullah Bakery's warehouse (A)	35	14,976	245168.89	54325.2
Ziq Bakery's warehouse (B)	51	15552	1161646.2	703195.2
Sweeden Bakery's warehouse (C)	46	15360	406883.2	67534.3

4.3 DATA ANALYSIS

Data analysis is analyzing and interpreting the results from the graph and statistic results of the DEA software. The collected statistic result are number of labor, working hour, cost, and sales to observe the efficiency the use of the resource by the warehouse from the data element that was key it in the CCR model before be run in the software. The number of labor is the number of labor that is work in the warehouse while the working hour is the hour that the labor work. The cost is the cost that is needed to operate the warehouse and the sales is the sales of the product of the warehouse.

The result from the CCR model can be present in the form of table, graph and statistics. The result of the efficiency of the warehouse will be analyze and be ranked as the number one which it can be as a benchmark to the other warehouses.

4.3.1 Slack of the Variables

Table 4.2: Slack of the variables

No.	DMU	Score	Excess no. of Employees S-(1)	Excess Working Hour S-(2)	Excess Cost S-(3)	Excess Sales S+(1)
1	Warehouse A	0.3360	8.8716	4280.4167	0	0
2	Warehouse B	1	0	0	0	0
3	Warehouse C	0.2742	7.7148	2717.9667	0	0

The above result show the slack analysis of the variables for the Ziq Bakery's warehouse, Sweeen's warehouse and Abdullah bakery's warehouse which it is represent by warehouse B, A and C. A slack analysis is one of the most best insights provided by the DEA. It is the set of target values for the DMUs to be improve through specific recommendations. Slack anaysis provides valuable information for the warehouse owner and managers, regarding their warehouse's efficiency decision making process. Input and output slacks are identified for the warehouse characterized by technical efficiency.

Furthermore, the result of input and output slacks in Table 4.1 derived from the efficiency index (CCR), for the warehouses. For interpreting the content of the table, which is warehouse A should make two adjustment, in input terms, in order to operate 100 percent efficiency. First, it would have to reduce its number of employee by 8 persons (from 35 to 27) while second, it should reduce its working hour by 4280 hours (from 14,976 to 10,696).

While for warehouse C, it also should make two adjustment for working hour and number of employee. It would have to reduce its number of employee by 7 persons (from 46 to 39) and it should reduce its working hour by 2717 hours (from 15,360 to 12,463).

The above analysis indicates that both warehouse should make adjustments in their working hour and number of employee.

Table 4.3: Table of the Score of the Warehouse Efficiency

Rank	DMU	Score
1	Warehouse B	1
2	Warehouse A	0.3660
3	Warehouse C	0.2742

4.3.2 Projection of the Warehouse

Table 4.4: The projection of the warehouse

No.	DMU I/O	Score Data	Projection	Difference	%
1	Warehouse A	0.3660			
	No of employee	35	3.9399	-31.0600	-88.74%
	Working Hour	14976	1201.4665	-13774.5335	-91.98%
	Cost	245168.89	89742.7374	-155426.1526	-63.40%
	Sales	54325.2	54325.2	0	0.00%
2	Warehouse B	1			
	No of employee	51	51	0	0.00%
	Working Hour	15552	15552	0	0.00%
	Cost	1161646.2	1161646.2	0	0.00%
	Sales	703195.2	703195.2	0	0.00%
3	Warehouse C	0.2742			
	No of employee	46	4.8980	-41.1020	-89.35%
	Working Hour	15360	1493.6015	-13866.3985	-90.28%
	Cost	406883.2	111563.5644	-295319.6356	-72.58%
	Sales	67534.3	67534.3	0	0.00%

The table has shown the score data for the warehouse A (Sweeden Bakery's warehouse), B (Ziq Bakery's warehouse) and C (Abdullah bakery's warehouse). From the analysis result of CCR Model it show that the warehouse B is efficient which is score 1 so it is rank as 1. Its result shows that the numbers of inputs were used efficiently for the output so the projection value is same for both inputs and output. While, for warehouse C is high value of inefficient which is 0.2742. For warehouse C, it

shows that the projection value for working hour is 1493 hours from 15360 hours which is the value that the warehouse C needs to be efficient. Its projection number is 4 person for the employee from 46 person score data. Moreover, warehouse C spend for RM406883.20 for inventory cost and it should spend for RM111563.56 to become efficient. So the difference value it gets for the cost is RM29519.64 and for the working hour the difference value is 13,867 hours.

Furthermore, the warehouse A is also inefficient because it score value is 0.3660. The number of the employee that it has is 35 people and it should have only 3 people to achieve the efficiency of their warehouse. For working hour, it gets the projection value 1201 hours from 14976 hours of data. Warehouse A spend for RM245168.89 for inventory cost which it should spend at RM89742.74 for inventory cost to achieve the sales. So the difference value for the cost is RM155426.15 and for the working hour the difference value is 13775 hours.

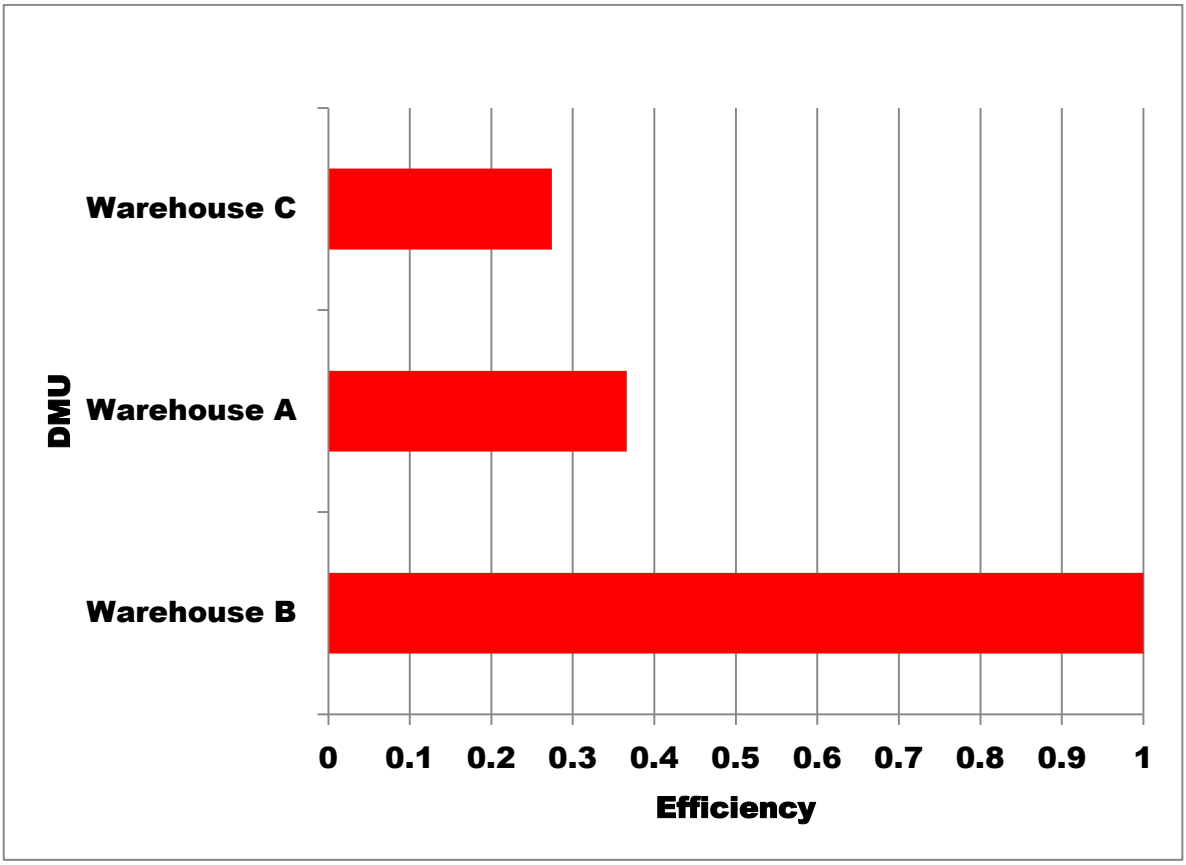

Figure 4.5: Graph of Warehouse Ranking following Efficiency

According to the figure above, the warehouse B is efficient because it show the score as 1 which is the best practice compare to the other warehouse. Meanwhile, the warehouse C gets the score value of 0.2741 and warehouse A is 0.3660. So, the warehouse B is suitable to be used as the benchmark to the warehouse A and warehouse C.

No.	DMU	Scre	Rank	Reference set (lambda)
1	Warehouse A	0.3660	2	Warehouse B
2	Warehouse B	1	1	Warehouse B
3	Warehouse C	0.2742	3	Warehouse B

Table 4.5: The Score and Rank for the Warehouses

The table shows the score and rank obtained for all of the DMUs. The warehouse A score value for efficiency is 0.3660 which is rank as number 2. While, the warehouse C score value is 0.2742 which is rank as number 2. Warehouse B is used as the reference as the benchmark for both of the warehouse A and C to become efficient.

Table 4.6: Statistics on Input and Output Data

	Number of employee	**Working Hour**	**Cost**	**Sales**
Max	51	15552	1161646.2	703195.2
Min	35	14976	245168.89	54325.2
Average	44	15296	604566.0967	275018.2333
SD	6.6833	239.4661	399409.1976	302814.8567

From the result above it show the statistics on input and output of the data warehouse. The maximum number of employee is 51 people while the minimum is 35 people. Its average is 44 people and standard deviation is 6 people.

The maximum value for working hour is 1552 hours and for the minimum value is 14976 hours. The average of the warehouse working hour is 15296 hours and standard deviation is 239 hours. Meanwhile, for the cost the maximum value is RM1161646.20 and minimum value is RM245168.89. The standard deviation is RM399409.20 and average is RM604566.10 for the cost. Lastly for the sales the maximum value is RM703195.20 and minimum value is RM54325.20. It average is RM275018.23 and standard deviation is RM302814.86.

Table 4.7: The Correlation of the variables

	No of employees	Working Hour	Cost	Sales
No of employees	1	0.9997	0.8415	0.7525
Working Hour	0.9997	1	0.8537	0.7675
Cost	0.8415	0.8537	1	0.9890
Sales	0.7525	0.7675	0.9890	1

The results show the correlation among the variables of working hour, number of employee, cost, and sales. The working hour and cost indicates the strong positive correlation which is 0.8415. Meanwhile, the cost and sales show that the value of coefficient is 0.9890 which indicates strong positive correlation between variables. The working hour and sales correlation coefficient is 0.3425 which show the strong positive correlation. Besides, the working hour and the number of employee, the correlation is 0.9997 that is strong positive correlation. The sales and working hour also indicates the strong positive correlation by 0.7675.

Table 4.8: Strength of correlation coefficients

Value of r	Comment
$r = -1.0$	Perfect negatively correlated where all the data fall on the line of negative slope
$-1.0 < r \leq -0.7$	Strong negatively correlated
$-0.7 < r \leq -0.5$	Moderate negatively correlated
$-0.5 < r < 0$	Weak negatively correlated
$r = 0.0$	No correlation between two variables
$0.0 < r < 0.5$	Weak positively correlated
$0.5 \leq r < 0.5$	Moderate positively correlated
$0.7 \leq r < 1.0$	Strong positively correlated
$r = 1.0$	Perfect positively correlated where all the data fall on the line of positive slope

4.4 DATA VERIFICATION AND VALIDATION

Data verification and validation process are very important process to get the CCR model running accurately. The CCR model can be proceeding when the input and output are arrange in according manner as the guideline of the data must be arrange in Excel sheet when using the DEA Software.

Verification of the model can be grouped into two aspects which is design of the model and implementation. Fully understanding about the specification of the DEA Software module is very crucial to build the CCR model according to the research study which wants to know the measure efficiency of the warehouse. The flow and arrangement of the CCR model must follow as the guideline if not the model cannot be run as expected. Besides, the variables to be use in the CCR model must be same for the entire warehouse and the data must be the real as apply of the warehouse. The implementation of the CCR model will represent the efficiency of the warehouse in real situation when all the desired information and data was key it in the software module.

Furthermore, the validation process also can be divided into two categories which are conceptual validation and result validation. Conceptual validation is occurred when the anticipated fidelity of the model is assessed. Meanwhile, result validation is occurred when the result of the CCR model showing the most efficient based on efficient use of resources of the warehouse compare to the others. The results from the software will show which warehouse is efficient compare to the other so it can be used as the benchmark to the warehouse. Others than that, the results also will show how many inputs resources that actually the warehouse need to achieve the effective output to become more efficient.

The result that we get from analysis shows that the warehouse B is efficient compare to other warehouse. Warehouse A score value is 0.36604 while warehouse C score value is 0.2742. From the result, it is prove that the result is valid because we can determine which warehouse score value is one that is suitable to be used as the benchmark for other warehouse. Therefore, the DEA software can be accepted valid.

Furthermore, the information and data that we collect are based on reference of the best practice in the warehouse to support the validity of the result. The DMUs and variables are the subject to the validation. The results were valid because it was reviewed from

the decision makers from the respective organization of the warehouse. The variables are also taken from the past historical data in the research journal. 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.

From the result, it is show that the CCR model by using the DEA software able to run completely to get the statistic output and the best warehouse which is efficient. This is an evidence to prove that The DEA software has no any errors. So, the validation of the model is strong because this CCR model can be run completely where it is can determine which warehouse is efficient and can be used as the benchmark. It can conclude that this CCR model is valid and significant to be use by the other researcher to measure the efficiency in any kind of field. Then, the next step will be able to continue which is data analysis.

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CHAPTER 5

MODEL EXPERIMENTATION AND CONCLUSION

5.1 INTRODUCTION

In this chapter, there will be a series of discussion on the model experimentation. According the CCR model from the previous chapter, the inputs of the number of the resources must be change so the resources can be use more efficient and will we get the better production output. The inputs must be utilized by reducing or adding more resources. From the results that were obtained from the CCR Model, a recommendation will be give to improve the results efficient of the warehouse.

5.2 RESULT DISCUSSION

The analyzing of the CCR model was carried out in the previous chapter by analyze the projection, slack, and correlation of the variables in the CCR model. The results of the original CCR model was discussed in the chapter 4, but in this chapter, we will explain about chapter 1 in more detailed for the results and some recommendations were give to improve the efficiency of the warehouse.

From the analyzing and interpreting on the previous chapter, the measuring the efficiency of the warehouse was determined. From the results, the efficiency warehouse

was determined and warehouse B which is Ziq Bakery's warehouse that is efficient. So, it is used as the benchmarking for the other warehouse. The warehouse B is efficient because it show the score as 1 which is the best practice compare to the other warehouse. Meanwhile, the warehouse C (Sweeden Bakery's warehouse) gets the score value of 0.2741 and warehouse A (Abdullah bakery's warehouse) is 0.3660. So, the warehouse B is suitable to be used as the benchmark to the warehouse A and warehouse C.

The slack of the result providethe information for the warehouse owner and manager. It show that the excess of number of employee and working hour for the Sweeden's warehouse and Abdullah's warehouse. So, it is should be reduce to improve for their warehouse efficiency which will help in their warehouse's efficiency process. The analysis indicates that both warehouse should make adjustments in their working hour and number of employee to improve their efficiency.

For warehouse C, it shows that the projection value for working hour is 1493 hours from 15360 hours which is the value that the warehouse C needs to be efficient. Its projection number is 4 people for the employee from 46 person score data. Moreover, warehouse C spend for RM406883.20 for inventory cost and it should spend for RM111563.56 to become efficient.

Furthermore, the warehouse A is also inefficient because it score value is 0.3660. The number of the employee that it has is 35 people and it should have only 3 people to achieve the efficiency of their warehouse. For working hour, it gets the projection value 1201 hours from 14976 hours of data. Warehouse A spend for RM245168.89 for inventory cost which it should spend at RM89742.74 for inventory cost to achieve the sales.

From overall observation, the result indicates that there is a strong positive correlation between variables among the working hour, number of employee, cost, and sales. There is strong positive correlation between the number of employee and working hour by 0.9997. Meanwhile, the sales and working hour correlation coefficient is 0.7675 which show the strong positive correlation.

5.3 CONCLUSION

The objective of this study is to evaluate the efficiency of the warehouse of the Ziq Bakery, Sweeden Bakery and Abdullah Bakery in Kuala Terengganu. In order to achieve the objective of this study, there are many information was study to get the current information about the DEA model. DEA model can be used by worldwide because it is powerful method to measure the efficiency of the DMU. Thus, it can help many industries to solve the problem by using this DEA method. The warehouse managers may benefit from DEA analysis simply by learning how their performance compares to the hypothetical "best practice" performance.

In this CCR model, there are three inputs and one output and three numbers of DMUs was used to evaluate the efficiency of the warehouse. The inputs that we are used are number of employers, working hour, cost operation while the outputs are sales. All of the information and data were key it in the Excel sheet before be run into the DEA Training Version Software.

The information and data must be accurate based on the warehouse before be run in the DEA Software. The verification and validation of the information and data can be made after running the CCR model in the software and refer to expert to be as the reference of the validity of the data. In this study, the slacks were identified and the improvement of the DMUs was recommended. The slack was detected at the number of employees and their working hour.

As a conclusion, DEA technique can help the warehouse to solve the problem by use the efficient warehouse as the benchmark to other warehouse. So, the manager of the warehouse will know what the lack of the management of the warehouse and improve it to be more efficient based on the result which can know by using this DEA software. It will reduce the cost of the warehouse because the resources will be utilized when the manager know the excess or shortage of the resources. By using this software, it can save the time and cost for manager to expand for finding the problem of the warehouse because not been efficient.

5.4 LIMITATIONS

In this study, the limitation of the efficiency of the warehouse using DEA was discussed. With respect to the sample of warehouses, its representative is questionable since in this research it only chooses a few numbers of warehouses to be used in the CCR Model. However, since this is the first warehouse efficiency study in this model, the sample data was also based on the collection from the warehouse itself and the information of data elements was referred from the past historical journal.

The time need of the research is really limited for the collection of data in the warehouse so the data that was obtained only in few of warehouses. Thus, the decision making units is only in small quantity that was obtained. There is also lack of time in this research because have other commitment to fulfill which is to find the related article for this study. So there is need a lot of time for fully understanding in this research. During complete this research, there is barrier because it is difficult to find the network connection and it will limit the research to go further.

Besides, The DEA methodology applied in the current study is the basic one and was choose because of the two reasons. Firstly, because this is the first study of warehouse efficiency ofZiq Bakery, Abdullah Bakery and Sweeden Bakery. The objective in this study to evaluate the performance efficiency value of warehouse. Secondly, because this DEA methodology is the most adopted one in the relevant literature, make this study result comparable with the other relevant literature. The warehouse managers may benefit from DEA analysis simply by learning how their performance compares to the hypothetical best practice performance. However, there is another source of benefit from a large scale DEA study learning what characteristics of warehouses seem to be correlated with good performance.

On other hand, the researcher should use some level of caution for interpret the results as the findings was based on data collected only from journal papers, and articles published in books. Thus, the results of DEA do not include all real world DEA publications. We have reviewed only academic or professional journal articles. The working research papers, conference presentations which is not published yet are excluded, as we assume that high quality research would be published in the every journals were covered. Moreover, there are also many foreign and newer journals might

not have been included which there are not use English language publications. The journal review process often take a more time so some research reported in the survey may lag behind the actual using of the recommendation.

5.5 RECOMMENDATION

From this research, we can measure the efficiency of the warehouse using DEA technique. The efficiency of the warehouse was determined by CCR model which can be use as benchmark to the other warehouse. My suggestion for this warehouse is to utilize of all the resources that they had. The manager of the warehouse should reduce some number of employees so that the manager can save the cost operation in the warehouse.

Other than that, the greatly expanding the number of participating of the warehouse will identify best practice of the warehouse. This is because the statistical approach to identifying the best practices will be successful only if a large number of warehouses are participates. There is recommend to put as many number of warehouse as possible in our current sample.

DEA technique is a powerful method to measure the efficiency of the DMUs in real situation by using DEA Software. This software can be use in the many different kinds of fields in industry. The consideration to include as many DMUs as possible is a greater probability of capturing high performance that would improve discriminatory power. The focus on more o the type of data to be put it in the software will benefit to get the better result for efficiency value. Then, it can also get the solution to solve the problem. Lastly, the timeline to complete the research must be in detail and schedule to ensure the research proceeding smoothly. Fully understanding and define the best of sources to get the reliable information is also important to make sure the research is significant.

This study is recommended to be further developed by other researcher. There are a lot of applications of DEA which can be developed. Thus, it is encouraged for further study by researchers which approach the DEA for most powerful application such extend the traditional DEA model to be fuzzy framework which is done by other

passed researcher. Furthermore, it is also recommend to hybrid the DEA with the other benchmarking method so that it used can be maximize for many advantage to the organization.

The DEA method is not much used by the industry in our country, so there is recommend using this method because we can get a lot of benefit from it. Nowadays, there are many companies out there in overseas trying to use DEA in various kind of field because they known DEA is the powerful method to measure efficiency. The DEA method will surely give many benefits for many department which they know how well efficient their company. However in Malaysia, the DEA method is not well known much by people. The thesis about DEA method is not much study by the student in our country.

BIBLIOGRAPHY

Agarwal, S. (2014). Efficiency Measure by Fuzzy Data Envelopment Analysis Model. *Fuzzy Information and Engineering*, 59-70.

Angiz, M. Z. (2013). Cross-ranking of Decision Making Units in Data Envelopment Analysis. *Applied Mathematical Modelling*, 398–405Majid Zerafat Angiz.

Appa, G. a. (2011, JANUARY 11). *A formula for the solution of DEA models.* London: LSE.

Bowlin, W. F. (2012). Measuring Performance: An Introduction to Data Envelopment Analysis (DEA). *The Journal of Cost Analysis*, 3-27.

Data envelopment analysis. (2015, February 2). Retrieved from Wikipedia: https://en.wikipedia.org/wiki/Data_envelopment_analysis

Fang, C. J. (2010). Using Data Envelopment Analysis to Evaluate the Performance of Third. *Journal Article*.

Fang, C.-J. T.-L. (2010). Using Data Envelopment Analysis to Evaluate the Performance of Third. *Journal Article*.

Jain, S. (2011). Manufacturing performance measurement and target setting: A data. *European Journal of Operational Research*.

Johnson, A. (2006). METHODS IN PRODUCTIVITY AND EFFICIENCY ANALYSIS. *Journal Article.*

Lertworasirikul, S. (2003). Fuzzy data envelopment analysis (DEA): a possibility approach. *Fuzzy Sets and Systems*, 379-394.

Mecit, E. D. (2001). A new proposed model of restricted data envelopment analysis by correlation coefficients. *Applied Mathematical Modelling*, 3407–3425.

Michael Mannino, S. N. (2008). Efficiency evaluation of data warehouse operations. *Science Direct*, 886-890.

Michael Mannino, S. N. (2008). Efficiency evaluation of data warehouse operations. *Decision Support Systems*, 883-898.

Sarkish, A. (2002). Preparing Your Data for DEA. *Productivity Analysis in the Service Sector with Data Envelopment Analysis*.

Vincova, K. (2005). USING DEA MODELS TO MEASURE EFFICIENCY.

Wade D. Cook, L. M. (2009). Data envelopment analysis (DEA) – Thirty years. *European Journal of Operational Research*, 1-17.

Whittaker, G. (2009). A hybrid genetic algorithm for multiobjective problems with. *European Journal of Operational Research*, 195-203.

William W. Copper, L. M. (2007). *Data Envelopment Analysis.* USA: Springer Science+Business Media LLC.

APPENDIX

A WORK PROGRESS OF UNDERGRADUATED RESEARCH PROJECT 1

PROGRESS/RESEARCH ACTIVITY	WEEK													
	1	2	3	4	5					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														