European Journal of Scientific Research
ISSN 1450-216X Vol.52 No.4 (2011), pp.476-486

http://www.eurojournals.com/ejsr.htm

# An Efficiency Analysis of Projects Using DEA

**Ku Ruhana Ku-Mahamud**
*Graduate Department of Computer Science, College of Arts and Sciences*
*Universiti Utara Malaysia, 06010 Sintok, Kedah, Malaysia*
E-mail: ruhana@uum.edu.my

**Maznah Mat Kasim**
*Graduate Department of Computer Science, College of Arts and Sciences*
*Universiti Utara Malaysia, 06010 Sintok, Kedah, Malaysia*
E-mail: maznah@uum.edu.my

**Nor Farzana Abd. Ghani**
*Graduate Department of Computer Science, College of Arts and Sciences*
*Universiti Utara Malaysia, 06010 Sintok, Kedah, Malaysia*
E-mail: farzana@uum.edu.my

**Fader Abdullah**
*Faculty of Business Management, Universiti Teknologi MARA, 02600 Arau, Perlis, Malaysia*
E-mail: fader@perlis.uitm.edu.my

**Abstract**

This paper presents a model to measure the efficiency of products produced by organization. The products are the projects carried out by the selected organization. The model which has been developed was based on data envelopment analysis, optimizes a ratio of multiple weighted outputs to a multiple weighted inputs. This non-parametric model is simple and yet very powerful because it can consider multiple outputs and inputs simultaneously. Descriptive analysis of the data, relative efficiency results, peer group analysis and projection for inefficient projects are presented. The proposed efficiency model is simple and practical in implementation. It is hope that the projects which act as the decision making unit can later be used to determine the efficiency of the company department/unit that housed the projects.

**Keywords:** Data envelopment analysis, efficiency measurement model; project efficiency; non-parametric model

## 1. Introduction

Organizational performance is a critical requirement for an organization to survive in the market. One of the approaches to determine the organizational performance is through performance measurement. Measuring business performance and presenting the resulting information for action is one aspect of achieving business success. Langdon (2000) stated that performance is the results of organization's effort to achieve its goals or objectives. March and Sutton (1997) explained that good performance indicates that the organization's practice is working well according to plans while poor performance indicates that practice does not work according to the plans. Efficiency measurement is one of the most important components in measuring organizational business performance. Efficiency is measured with a target to the organization's goals for example maximization outputs, maximization of profits or minimization of costs. The theory of efficiency is related to the association between resources used and results achieved. The efficiency measurement deals with the way how an organization uses the resources in a best way to produce output. The optimization of resources can amplify the efficiency and competitiveness of the organization.

There are many techniques exist to measure the efficiency of an organization. These techniques are usually classified into two main approaches, parametric and non-parametric. Parametric approaches specify functional form and take into account residual term in the analysis while the non-parametric approaches put less structure on the specification of the best practice frontier and assume no random error (Huth and Pokorna, 2004). The main difference between both of the approaches is the distribution of the data. Parametric approaches concern with normality of the data distribution while non-parametric approaches do not. There are many advantages of non-parametric method as compared to the parametric ones. For instance non-parametric approaches are simple and less affected by outliers. These approaches do not require information about the distribution and the variance of the data. Besides that, non-parametric methods do not care about the relationship between the sets of the data. Generally, these methods do not require assumption about the data, and can be used in a broader range of data.

Efficiency measurement using non-parametric approach had originated from the attempt to evaluate the efficiency of units that produce multiple outputs with multiple inputs in a situation where input and/or output prices were hardly available (Glawischnig and Sommersguter-Reichmann, 2010). Several types of non-parametric approach are available and among them, is the data envelopment analysis (DEA) which was developed by Charnes et al. (1978) as a tool for evaluating and improving the performance of manufacturing and service operations.

DEA is a linear programming model that provides a mean of calculating apparent efficiency levels within a group of organizations. In Bhagavath (2006), the efficiency of an organization was calculated relative to the group's observed best practice. It was particularly well suited for efficiency evaluation when the organization's efficiency was measured along multiple dimensions. When linked with an adjustment process that accounts for the organization's operating conditions, DEA would produce efficiency scores that neither rewarded organizations that were fortunate enough to operate under favorable conditions nor penalized those that operated under unfavorable conditions (Sexton and Comunale, 2004).

DEA approach was used to estimate the overall, pure technical and scale efficiencies for Malaysian commercial banks during the period 2000-2006 (Tahir et al., 2009). The results suggested that domestic banks were relatively more efficient than foreign banks. It also suggested that domestic banks' inefficiency were attributed to pure technical inefficiency rather than scale inefficiency. In contrast, foreign banks inefficiency was attributed to scale inefficiency rather than pure technical inefficiency. The study further examined whether the domestic and foreign banks were drawn from the same environment by performing a series of parametric and non-parametric tests. The results from the parametric and non-parametric tests suggested that for the years 2000-2004, both domestic and foreign banks possessed the same technology whereas results for 2005 and 2006 suggested otherwise.

Models for measuring the efficiency of decision making unit (DMU) within an organization have been proposed by Cooper et al. (2007), Inoni (2007), Barros (2004) and Athanassopoulos and Shale (1997). However, to the best of our knowledge those models were not able to be used to measure business efficiency for product within an organization or company. This study has focused on developing business efficiency measurement model based on product within an organization using DEA approach. DEA is a multi-variable model for measuring the relative efficiency of a homogeneous set of DMUs. The efficiency score for each DMU is equal to a ratio of weighted sum of multiple outputs to weighted sum of inputs, and is to be optimized as many times as the total number of DMUs.

This means that the efficiency scores are computed in the presence of multiple outputs and inputs simultaneously and the weights for inputs and outputs are not unique. Based on the advantages of DEA, this study will employ this technique to develop business efficiency measurement model based on product produced by the DMU of an organization.

For this study, the term DMU is interchangeable with product. Products are projects undertaken by the company. This study will provide a model to measure business efficiency of an organization based on product which will indirectly leads to measuring business efficiency of individual units within an organization.

## 2. Case Background

The organization that has been used as a case study for the research is In-Fusion Solutions Sdn. Bhd. (ISSB). ISSB offers advanced and innovative e-learning solutions to the global community. ISSB was established in 2002 with the vision of optimizing the technology for learning and new media and to be the premier information and communication technology company, providing virtual education solutions in a full converging environment. ISSB offers advanced and innovative e-learning solutions to the global community. As an education solution and services provider, ISSB core products includes from courseware, enterprise resource planning system for the education environment, educational games, learning content management system, student information management system, integrated campus management system, Islamic banking and finance program, knowledge information exchange system and portal experience.

The selection of DMUs is very crucial in measuring their relative efficiency. This study defines DMUs as the projects in organization that have the same function such as produce product or services. 39 projects were chosen to be analyzed as they are 100 percent completed. The project is divided into two different types which are the hardware projects (H) and courseware projects (C). These data were obtained from company documents such as annual reports and other published documents.

## 3. Proposed Efficiency Model

The collected data and information were analyzed to determine the inputs and output appropriate to be used in developing the model to measure the efficiency of the DMUs. The general rule of thumb states that the number of DMUs must be more than or equal to three times the sum of inputs and outputs (Raab and Lichty, 2002).

Three inputs and one output have been identified as the most appropriate to be included in the efficiency measurement model. The inputs chosen are the labor, material and project duration and the output is the project contract value. The inputs are considered as significant components in determining the efficiency of the project. Labor (measured in Ringgit Malaysia) reflects the sum of all the salaries of the employees involved in completing the project. The project is completed with the cooperation between the employees in finishing the task. The second input which is material, is the total cost of equipments such as the software and hardware used in the projects. The equipment cost includes the cost of equipment rental and the purchase of new equipment. This is also measured in Ringgit Malaysia. Materials used in one project are assumed differ from other projects. Projects must be completed in the stipulated time frame. Delay in project completion will cause loss to the organization. Thus the project duration is one of the important factors that need to be considered as the input in this efficiency model. Project duration is measured in months. The contract value is selected as the output because it reflects the revenue obtained by the company. There is no other variables/data available that can best describe the value of the project. Table 1 shows the list of the 39 projects with the respective inputs and output. The cost for material will be zero if a project utilized existing hardware and software.

**Table 1:** Data Inputs and Output for Efficiency Analysis of Projects

| PROJECT | INPUT | | | OUTPUT |
|---|---|---|---|---|
| | LABOR (RM) | MATERIAL (RM) | PROJECT DURATION (MONTHS) | CONTRACT VALUE (RM) |
| H1 | 90,000.00 | 2,385,547.20 | 6 | 2,650,608.00 |
| H2 | 480,000.00 | 673,058.00 | 24 | 1,346,116.00 |
| H3 | 6,000.00 | 895,233.60 | 1 | 1,053,216.00 |
| H4 | 6,000.00 | 950,000.00 | 1 | 1,000,000.00 |
| H5 | 48,000.00 | 5,000.00 | 3 | 190,305.00 |
| H6 | 3,000.00 | 169,960.50 | 0.25 | 188,845.00 |
| H7 | 3,000.00 | 151,893.90 | 0.25 | 168,771.00 |
| H8 | 3,000.00 | 129,933.90 | 0.25 | 144,371.00 |
| H9 | 15,000.00 | 80,000.00 | 0.25 | 149,250.00 |
| H10 | 15,000.00 | 63,129.50 | 0.25 | 74,270.00 |
| H11 | 6,000.00 | 59,376.75 | 0.25 | 69,855.00 |
| H12 | 20,000.00 | 55,827.20 | 2 | 69,784.00 |
| H13 | 12,000.00 | 3,000.00 | 1 | 42,800.00 |
| H14 | 3,000.00 | 17,918.85 | 0.25 | 21,081.00 |
| C1 | 600,000.00 | 0.00 | 12 | 1,000,000.00 |
| C2 | 473,450.00 | 0.00 | 24 | 557,000.00 |
| C3 | 1,190,000.00 | 0.00 | 12 | 1,400,000.00 |
| C4 | 290,700.00 | 0.00 | 12 | 342,000.00 |
| C5 | 670,548.00 | 0.00 | 12 | 788,880.00 |
| C6 | 36,000.00 | 0.00 | 12 | 513,218.00 |
| C7 | 7,000.00 | 0.00 | 2 | 237,125.00 |
| C8 | 15,000.00 | 0.00 | 2 | 101,214.00 |
| C9 | 12,000.00 | 0.00 | 3 | 100,000.00 |
| C10 | 48,000.00 | 0.00 | 12 | 99,900.00 |
| C11 | 60,000.00 | 0.00 | 6 | 90,000.00 |
| C12 | 60,000.00 | 0.00 | 6 | 75,000.00 |
| C13 | 15,000.00 | 0.00 | 3 | 70,000.00 |
| C14 | 40,000.00 | 0.00 | 6 | 45,000.00 |
| C15 | 15,000.00 | 0.00 | 1 | 43,890.00 |
| C16 | 12,000.00 | 0.00 | 4 | 30,200.00 |
| C17 | 20,000.00 | 0.00 | 1 | 28,000.00 |
| C18 | 12,000.00 | 0.00 | 1 | 20,000.00 |
| C19 | 17,000.00 | 0.00 | 0.5 | 19,550.00 |
| C20 | 5,000.00 | 16,515.00 | 3 | 18,350.00 |
| C21 | 15,000.00 | 0.00 | 1 | 15,000.00 |
| C22 | 10,000.00 | 0.00 | 1 | 13,035.00 |
| C23 | 9,000.00 | 0.00 | 0.5 | 10,000.00 |
| C24 | 6,000.00 | 0.00 | 3 | 7,500.00 |
| C25 | 9,000.00 | 0.00 | 2 | 9,800.00 |

A simple and easy way to measure efficiency of a unit or DMU which have one input and one output is to determine the ratio of output to the input. The general efficiency measure is given by:

$$\text{Efficiency} = \frac{\text{output}}{\text{input}}$$

The efficiency increases as the output value gets larger and the input gets smaller. However, in reality organization operates with the used of multiple inputs to produce multiple outputs. This becomes the drawback of efficiency measure which cannot utilize the situation where there is more than one input or more than one output. To overcome the problem, DEA has been used in this problem to measure efficiency that involves multiple inputs and single output.

Using DEA, the choice of optimal system of weights for a *j*th project involves solving a mathematical optimization model whose decision variables are the weights associated with each output and input. Various formulations have been proposed such as ratio, additive, multiplicative, Charnes, Cooper and Rhodes (CCR) and Banker, Charnes and Cooper (BCC) models. However, this study focuses on CCR model developed by Charnes et al. (1978).

The CCR model formulated for *j*th project takes the form

$$\text{maximize } \frac{w_1 y_{1j}}{\sum_{i=1}^{3} v_i x_{ij}} \tag{1}$$

subject to

$$\frac{w_1 y_{1j}}{\sum_{i=1}^{3} v_i x_{ij}} \leq 1, \quad \forall j, j=1,\ldots,39 \tag{2}$$

$$\text{and } w_1, v_i \geq 0, \tag{3}$$

where

$w_1$ = weight for output of type 1 of *j*th project,
$y_j$ = amount of output of type 1 of *j*th project,
$v_i$= weight of input of type *i* of *j*th project,
$x_{ij}$ = amount of input of type *i* of *j*th project,
$w_1$ and $v_i \geq 0$, for $j = 1\ldots,39$ and $i = 1,\ldots,3$.

The objective function (1) and constraints (2) and (3) composed of fractions and need to be transformed into linear form so that the model can be solved using simple linear programming.

The output orientation and input orientation models have been used to analyze the efficiency of the projects. In the output orientation model, objective function is given by:

$$\text{Maximize } w_1 y_{1j} \tag{4}$$

Subjects to

$$w_1 y_{1j} - \sum_{i=1}^{3} v_i x_{ij} \leq 0, \quad \forall j, j=1,\ldots,39$$

$$\sum_{i=1}^{3} v_i x_{ij} = 1 ,$$

$$w_1, v_i \geq 0$$

Equation (4) is a linear equation. It constrains the weighted sum of inputs to be unity and maximizes the weighted sum of outputs at the *j*th unit choosing appropriate values of $w_1$ and $v_i$.

In the input orientation model, the objective function is

$$\text{Minimize } \sum_{i=1}^{3} v_i x_{ij} \tag{5}$$

subjects to

$$\sum_{i=1}^{3} v_i x_{ij} - w_1 y_{1j} \geq 0,$$

$$w_1 y_{1j} = 1,$$

$$w_1, v_i \geq 0$$

Model (5) is also a linear equation. It constrains the weighted sum of outputs to be unity and minimizes the weighted sum of inputs at the *j*th unit choosing appropriate values of $v_i$ and $w$.

The input orientated model emphasizes on how to use minimum input resources to achieve a given level of output while the output oriented model focuses on using a given set of input to achieve the maximum possible output. The relative efficiency of the projects selected can be measured through any of these two models.

The proposed efficiency model is simple and practical in implementation and it is hope that the projects which act as the DMU can later be used to determine the efficiency of the company department/unit that housed the projects.

## 4. Experimental Results and Analysis

The summary of the data is shown in Table 2 and it could be observed that the mean, maximum and minimum labor used is RM 111,735.84, RM 1,190,000.00 and RM 3,000.00 respectively. The mean for material is RM 145,035.75 with the maximum value of RM 2,385,547.20 and the minimum is RM 0.00. As for project duration, the mean, maximum and minimum are 4 months and 3 weeks, 24 months and 1 week respectively. The mean for project contract value is RM 328,306.00 ranging from RM 7,500.00 to RM 2,650,608.00.

**Table 2:** Summary for inputs and output data

| | LABOR (RM) | MATERIAL (RM) | PROJECT DURATION (MONTHS) | CONTRACT VALUE (RM) |
|---|---|---|---|---|
| Maximum | 1,190,000.00 | 2,385,547.20 | 24 | 2,650,608.00 |
| Minimum | 3,000.00 | 0.00 | 0.25 | 7,500.00 |
| Mean | 111,735.84 | 145,035.75 | 4.66 | 328,306.00 |
| Std. Deviation | 243,069.04 | 427,092.22 | 5.989 | 538,036.73 |

Charnes et al. (1985) states that all inputs used must be positively related to the output produced to ensure the validation of DEA model. Correlation analysis is suitable in analyzing the data, testing the pattern and checking the relationship between the two variables.

Table 3 shows the correlation relationship between the inputs and the output. The analysis shows that both labor and material have high positive correlation value, *r*, and large *p* value with contract value, at significant level of 0.01 level (2-tailed). Although the *r* value between project duration and project contract value is 0.457 (medium correlation) which is below 0.5, it still can be accepted because the significant level is at 0.01 level (2-tailed). Thus, it can be concluded that there are strong positive relationships between the independent variables and dependent variable and there are strong correlation relationships between all inputs and the output.

**Table 3:** Correlation relationship between inputs and output

| Correlation | | | | | |
|---|---|---|---|---|---|
| | | (I) Labor | (I) Material | (I) Project Duration | (O)Contract Value |
| (I) Labor | Pearson Correlation | 1 | -.019 | .680** | .526** |
| | Sig. (2-tailed) | | .908 | .000 | .001 |
| (I) Material | Pearson Correlation | -.019 | 1 | .063 | .822** |
| | Sig. (2-tailed) | .908 | | .703 | .000 |
| (I)Project Duration | Pearson Correlation | .680** | .063 | 1 | .457** |
| | Sig. (2-tailed) | .000 | .703 | | .003 |
| (O)Contract Value | Pearson Correlation | .526** | .822** | .457** | 1 |
| | Sig. (2-tailed) | .001 | .000 | .003 | |

**. Correlation is significant at the 0.01 level (2-tailed).
I: Input, O: Output

The relationship between inputs such as labor with project duration shows quite high correlation value ($r$ = 0.680) while material with project duration shows low correlation value ($r$ = 0.063) and labor and material shows negative correlation value ($r$ = -0.019). In real situation, it should be no relationship between inputs variables. This is because the correlation value obtained is just a numerical value and meaningless for relationship between all the inputs. If there is high relationship between the inputs, so one of the inputs needs to be eliminated in order to ensure there is no data overlapping (Charnes et al., 1985)

Table 4 shows the results of efficiency scores for efficient projects (score = 1) and inefficient projects (score < 1). From the results, only three projects, H3, H9 and C7, out of 39 projects are efficient, where H3 is at the first ranking, followed by H9 and C7. There are 36 projects which are not efficient with efficiency scores range from 0.037 to 0.984. Project C24 is the most inefficient project with the lowest efficiency score which is 0.0367. This condition happens because there is no balance between the three inputs used with the output produced. Project C24 is the project with the lowest contract value but the cost of labor used is high and the project duration is long. The same situation took place for other inefficient projects but with relatively different degree of seriousness. The inefficient projects with high scores would have little unbalance as compared to projects that have very low efficiency scores.

**Table 4:** Relative efficiency score of projects

| Rank | Project | Score | Rank | Project | Score |
|---|---|---|---|---|---|
| 1 | H3 | 1 | 21 | C19 | 0.330 |
| 2 | H9 | 1 | 22 | C9 | 0.281 |
| 3 | C7 | 1 | 23 | C4 | 0.240 |
| 4 | C3 | 0.984 | 24 | C17 | 0.236 |
| 5 | H4 | 0.949 | 25 | H12 | 0.218 |
| 6 | H6 | 0.893 | 26 | C13 | 0.197 |
| 7 | H7 | 0.876 | 27 | C2 | 0.196 |
| 8 | H8 | 0.860 | 28 | C18 | 0.169 |
| 9 | H1 | 0.788 | 29 | C23 | 0.169 |
| 10 | C1 | 0.703 | 30 | C21 | 0.127 |
| 11 | H11 | 0.668 | 31 | C11 | 0.127 |
| 12 | H10 | 0.599 | 32 | C22 | 0.110 |
| 13 | C5 | 0.554 | 33 | C12 | 0.105 |
| 14 | H5 | 0.524 | 34 | C20 | 0.099 |
| 15 | C8 | 0.427 | 35 | C16 | 0.074 |
| 16 | C6 | 0.421 | 36 | C10 | 0.070 |
| 17 | H14 | 0.392 | 37 | C14 | 0.063 |
| 18 | C15 | 0.370 | 38 | C25 | 0.041 |
| 19 | H2 | 0.349 | 39 | C24 | 0.037 |
| 20 | H13 | 0.348 | | | |

Peer group analysis has been performed to compare projects that are not efficient with projects that are efficient so that the performance of the inefficient units can be improved (Charnes et al., 1989; Thanassoulis et al., 1987; Bowlin, 1986) by using reference sets which comprise of efficient projects. Table 5 shows the reference sets for each inefficient project.

**Table 5:** Reference set for inefficient projects (mark X)

| Inefficient Projects | Efficient Projects | | | Inefficient Projects | Efficient Projects | | |
|---|---|---|---|---|---|---|---|
| | H3 | H9 | C7 | | H3 | H9 | C7 |
| C3 | X | | X | C9 | | | X |
| H4 | X | | | C4 | | | X |
| H6 | X | X | X | C17 | | | X |
| H7 | X | X | X | H12 | | X | X |
| H8 | X | X | X | C13 | | | X |
| H1 | X | X | X | C2 | | | X |
| C1 | | | X | C18 | | | X |
| H11 | X | X | X | C23 | | | X |
| H10 | | X | X | C21 | | | X |

**Table 5:** Reference set for inefficient projects (mark X) - continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C5 | | X | X | C11 | | | X |
| H5 | | | X | C22 | | | X |
| C8 | | | X | C12 | | | X |
| C6 | | | X | C20 | X | | X |
| H14 | | X | X | C16 | | | X |
| C15 | | | X | C10 | | | X |
| H2 | | X | X | C14 | | | X |
| H13 | | X | X | C25 | | | X |
| C19 | | | X | C24 | | | X |
| **Total Frequency as Reference Set** | | | | | **8** | **11** | **15** |

The reference sets for inefficient projects are chosen from the same pattern factor value and not because they have the same characteristics (Nooreha et al., 2000). In this study, project C7 is the most frequent project that has been used as the reference set for inefficient projects. Consequently, project C7 is identified as the best and has been referred 35 times. The second best project is H9 which is referred 11 times, followed by project H3, referred 8 times by the inefficient projects.

The projections for inefficient projects are made by using the reference sets. For each inefficient project, its reference set together with its respective dual weight to improve the efficiency score. The dual weights for each inefficient project for input orientation and output orientation are as shown in Table 6.

**Table 6:** Inefficient projects and its dual weight value from input orientation and output orientation

| **Input Orientation** | | | | **Output Orientation** | | | |
|---|---|---|---|---|---|---|---|
| **Inefficient Projects** | **Efficient Projects** | | | **Inefficient Projects** | **Efficient Projects** | | |
| | **H3** | **H9** | **C7** | | **H3** | **H9** | **C7** |
| C3 | | | 5.904 | C3 | | | 6.000 |
| H4 | 0.949 | | | H4 | 1.000 | | |
| H6 | 0.160 | 0.106 | 0.018 | H6 | 0.179 | 0.119 | 0.021 |
| H7 | 0.139 | 0.107 | 0.027 | H7 | 0.159 | 0.122 | 0.030 |
| H8 | 0.114 | 0.108 | 0.036 | H8 | 0.134 | 0.127 | 0.042 |
| H1 | 1.784 | 3.534 | 1.030 | H1 | 2.264 | 4.484 | 1.307 |
| C1 | | | 4.217 | C1 | | | 6.000 |
| H11 | 0.023 | 0.238 | 0.042 | H11 | 0.034 | 0.357 | 0.063 |
| H10 | | | 0.016 | H10 | | 0.789 | 0.026 |
| H5 | | | 0.782 | H5 | | 0.063 | 1.492 |
| C8 | | | 0.427 | C8 | | | 1.000 |
| C6 | | | 2.164 | C6 | | | 5.143 |
| H14 | 0.003 | 0.059 | 0.040 | H14 | 0.007 | 0.149 | 0.103 |
| C15 | | | 0.185 | C15 | | | 0.500 |
| H2 | | 2.940 | 3.826 | H2 | | 8.413 | 10.948 |
| H13 | | 0.013 | 0.172 | H13 | | 0.038 | 0.495 |
| C5 | | | 3.327 | C5 | | | 6.000 |
| C19 | | | 0.082 | C19 | | | 0.250 |
| C9 | | | 0.422 | C9 | | | 1.500 |
| C4 | | | 1.442 | C4 | | | 6.000 |
| C17 | | | 0.118 | C17 | | | 0.500 |
| H12 | | 0.152 | 0.199 | H12 | | 0.698 | 0.913 |
| C13 | | | 0.295 | C13 | | | 1.500 |
| C2 | | | 2.349 | C2 | | | 12.00 |
| C18 | | | 0.084 | C18 | | | 0.500 |
| C23 | | | 0.042 | C23 | | | 0.250 |
| C21 | | | 0.063 | C21 | | | 0.500 |
| C11 | | | 0.380 | C11 | | | 3.000 |
| C22 | | | 0.055 | C22 | | | 0.500 |

**Table 6:** Inefficient projects and its dual weight value from input orientation and output orientation - continued

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| C12 | | | 0.316 | C12 | | | 3.000 |
| C20 | 0.002 | | 0.069 | C20 | 0.018 | | 0.698 |
| C16 | | | 0.127 | C16 | | | 1.714 |
| C10 | | | 0.421 | C10 | | | 6.000 |
| C14 | | | 0.190 | C14 | | | 3.000 |
| C25 | | | 0.041 | C25 | | | 1.000 |
| C24 | | | 0.032 | C24 | | | 0.857 |

From the input orientation, the projection focuses on how to reduce the inputs by maintaining the existing output, while from the perspective of the output orientation, the projection suggests an increment in output but maintaining the given inputs. For example, the projection of project H1 for input labor in the input orientation could be obtained by utilizing the efficient projects H3, H9, and C7 which react as the reference sets for project H1 to improve its efficiency score. The same goes to the projections for inefficient projects in the output orientation. The related mathematical formula for the projection of any inefficient project from the input orientation for the problem studied in this research is given as follows. Projection of the $i$th inefficient project

$$=\sum_{j=1}^{3} W_{ij} X_{ij}$$ , where $W_{ij}$ is the dual weight for $j$th reference set, and $X_{ij}$ is its input, for $j = 1,\ldots,3$

and $i= 1,\ldots,36$. In the output orientation, $X_{ij}$ will be replaced by $Y_{ij}$, the ouput of the $i$th reference projects. For example, by using the dual weights with respective reference sets, as shown on Table 7, projection for project H1 for labor (input) in the input orientation

= (dual weight)$_{H3}$(labor)$_{H3}$ + (dual weight)$_{H9}$(labor)$_{H9}$ + (dual weight)$_{C7}$(labor)$_{C7}$
= (1.784) (RM 6,000.00) + (3.53) (RM 15,000.00) + (1.03) (RM 7,000.00)
= RM 70,918.50.

While projection for project H1 for the contract value (output) in the output orientation
= (dual weight)$_{H3}$(contract value)$_{H3}$ + (dual weight)$_{H9}$(contract value)$_{H9}$
+ (dual weight)$_{C7}$(contact value)$_{C7}$
= (2.264) (RM 1,053,216.00) + (4.484) (RM 149,250.00) + (1.307) (RM 237,125.00)
= RM 3,363,787.00.

The original values of the inputs, the output and their respective projected values and the difference in percentage between the original and the projected for project H1 is portrayed in Table 7.

**Table 7:** The summary of the projection for project H1

| **Input Orientation** | | |
|---|---|---|
| Original Labor (RM)<br>90,000.00 | Projected Labor (RM)<br>70,918.49 | (%) Difference = Projected - Original<br>-21.2 |
| Original Material cost (RM)<br>2,385,547.20 | Projected Material Cost (RM)<br>1,879,771.34 | (%) Difference = Projected - Original<br>-21.2 |
| Original Project Duration<br>4 months and 3 weeks | Projected Project Duration<br>1 month and 1 week | (%) Difference = Projected - Original<br>-21.2 |
| **Output Orientation** | | |
| Original contact value<br>2,650,608.00 | Projected Contract Value (RM)<br>3,363,787.00 | (%) Difference = Projected - Original<br>+26.91 |

In input orientation, the inputs utilization should be minimized in order for the projects to get the efficiency score of 1 or to make the projects efficient. So, the inputs should be reduced down to certain value so that the inefficient projects can improve its efficiency score by reducing the inputs. In output orientation, the inputs are used in order to achieve the maximum amount of output production. The projects are efficient if the outputs are produced in maximum amount with the set of inputs given.

The projects which have the largest output increments are the project C16, C10, C14, C25 and C24. It can be observed that these 5 projects have the output increment up to 999.9%. However, the projects have to reduce some of the input to get the increment of 999.9%. The reduction of labor input for project C10, C14 and C25 are 12.5%, 47.5% and 22.22% respectively. The reduction of project duration input for project C16 and C24 are 14.29% (from 4 months to 3 months, 1 week and 5 days) and 42.86% (from 3 months to 1 month, 2 weeks and 6 days) respectively.

For the inputs orientation, the efficiency score of inefficient projects can be increased and improved by reducing the inputs to a certain level. The excess inputs are reduced and the inputs will be minimized. The minimum inputs used to produce the output will make the organization cut the cost up to RM 5,210,466.39 from original cost of RM 10,014,092.40.

For the output orientation, the given inputs are used to obtain maximum amount of output. The maximization of output will increase the organization contract value of projects up to RM 14,572,089.00 from original output of RM 12,803,934.00. However, some of the inputs need to be reduced in order for the output to have the increment. Project H2, H5, H10, H12, H13, C1, C2, C3, C4, C5, C8, C9, C10, C11, C12, C13, C14, C15, C17, C18, C19, C21, C22, C23 and C25 have to reduce their labor inputs in order to increase the contract value and efficiency score. Project H4 also needs to be reduced its material input to improve its efficiency score and project C6, C16, C20 and C24 need to reduce their project duration for them to improve their efficiency scores and the contract values. Meanwhile, only project H1, H3, H6, H7, H8, H9, H11, H14 and C7 do not need to reduce the inputs for output increment.

Until now, ISSB concentrated more on the output production which is the contract value but putting less care about the inputs utilization. Thus, some approaches need to be taken by the management to control the cost of inputs so that the projects can operate efficiently with the use of minimum inputs. Therefore, ISSB should strive to control expenditure in cost of labor, material and project duration so that the cost used is balanced with the output production.

## 5. Conclusion

The projects which are efficient used inputs with the right and ideal quantity to produce the output while the projects which are not efficient used inputs in excess quantity and made the organization's expenses increase. Therefore, the inefficient projects need to be improved by increasing its efficiency score so that inefficient projects can be transformed to be efficient.

In order to improve or increase the project's efficiency, management should reduce the inputs so that it can be balanced with the output production. Management also should find a way to reduce cost of labor, material and project duration in details without disturbing the production of output.

This research has revealed that organization's performance can be measured not only by analyzing the organization's business units but also by analyzing the projects produced by each business unit. The efficiency measurement model for products produced by organization has been developed. The model is simple and practical in implementation. The projects which act as the decision making unit can later be used to determine the efficiency of the company department/unit that housed the projects.

## Acknowledgement

The authors wish to thank the Ministry of Higher Education Malaysia for funding this study under Fundamental Research Grant Scheme, S/O code 11762 and RIMC, Universiti Utara Malaysia, Kedah for the administration of this study.

## References


[1] Athanassopoulos, A. and Shale, E. (1997). Assessing the comparative efficiency of higher education institutions in the UK by means of data envelopment analysis. *Education Economics*, 5, 117-134.

[2] Barros, C. (2004). Measuring performance in defense-sector companies in a small NATO member country. *Journal of Economic Studies*, 31, 112–128.

[3] Bhagavath, V. (2006). Technical efficiency measurement by data envelopment analysis: An application in transportation. *Alliance Journal of Business Research,* 60-72.

[4] Bowlin, W. (1986). Evaluating performance in governmental organizations. *The governmental Accountants' Journal*, 35, 50-57.

[5] Charnes, A., Cooper, W.W., & Rhodes, E. (1978). Measuring the efficiency of decision making units. *European Journal of Operational Research,* 2, 429-444.

[6] Charnes, A., Clark, T., Cooper, W.W. & Golany, B. (1985). A development study of data envelopment analysis: Measuring the efficiency of maintenance units in the US air force. *Annals of Operational Research,* 2, 95-112.

[7] Charnes, A., Clarke, R. & Cooper, W.W. (1989). An approach to testing for organizational slack via banker's game theoretic DEA formulations. Research in Governmental and Nonprofit Accounting, JAI Press, 5, 211-230.

[8] Cooper, W.W., Ruiz, J.L. and Sirvent, I. (2007). Choosing weights from alternative optimal solutions of dual multiplier models in DEA. *European Journal of Operational Research,* 180(1), 443-458.

[9] Glawischnig, M. and Sommersguter-Reichmann, M. (2010). Assessing the performance of alternative investments using non-parametric efficiency measurement approaches: Is it convincing? *Journal of Banking & Finance,* 34(2), 295-303.

[10] Huth, R. and Pokorna, L. (2004) Parametric versus non-parametric estimates of climate trends. *Theoretical and Applied Climatology*, 77, 107-112.

[11] Inoni O. E. (2007). Allocative Efficiency in Pond Fish Production in Delta State, Nigeria: A Production Function Approach. *Agricultura Tropica Et Subtropica*, 40, 127-134.

[12] Langdon, D. (2000). *Aligning performance: Improving people, systems, and organizations.* San Francisco: Jossey-Bass/Pfeiffer.

[13] March, J.G., Sutton, R.I. (1997). Organizational performance as a dependent variable. *Organization Science*, 8, 698-706.

[14] Nooreha, H., Mokhtar, A. and Kuman, S. (2000). Evaluating public sector efficiency with data envelopment analysis: A case study in road transport department, Selangor, Malaysia. *Total Quality Management*, 11, 830-837.

[15] Raab, R.L. and Lichty, R.W. (2002). Identifying Sub areas That Comprise A Greater Metropolitan Area: The Criterion of County Relative Efficiency, *Journal of Regional Science,* 42, 579-594.

[16] Sexton, T.R. and Comunale, C.L. (2004). An efficiency analysis of U.S. business schools. *Journal of Case Studies in Accreditation and Assessment,* 1-19.

[17] Tahir, I.M., AbuBakar, N.M. and Haron, S. (2009). Evaluating efficiency of Malaysian banks using data envelopment analysis. *International Journal of Business and Management,* 4(8), 96-106.

[18] Thanassoulis, E., Dyson, R. and Foster, M. (1987). Relative efficiency assessments using data envelopment analysis: An application to data on rates departments. *European Journal of Operational Research,* 38, 397-412.