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RESEARCH ARTICLE OPEN ACCESS

Business process efficiency measurement

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ABSTRACT
Business processes such as maintenance do the same or similar things day after day and for that reason, their performance must be measured on a regular basis. Measures of performance are needed in order to determine the productivity and the efficiency of an organization. Performance measurement also plays an important role in identifying and tracking progress against organizational goals. Data Envelopment Analysis (DEA) is one of the excellent tools to measure efficiency of business processes and DEA has been widely applied to perform efficiency analysis in many sectors.
Keywords: Performance measurement, Overall Equipment Effectiveness, Data Envelopment Analysis

I. INTRODUCTION

Every business activity is a production process and an organization is a complex set of processes with multiple inputs, production processes, outputs, and customers. Business processes are much like machines; they do the same or similar things day after day and for that reason, their performance must be measured on a regular basis. Measuring work inputs and product outputs is necessary to determine the work capacity and productivity of a process. Measures of performance have been used by management for centuries to review current operational capabilities such as departmental and corporate performance, as well as trend performance achieved based on organizational plan. These measures are needed in order to determine not only if resources and costs have been managed accurately based on achieved production and to determine whether the assets or plant remain in good health. . Performance measurement also play an important role in identifying and tracking progress against organizational goals as well as to identifying opportunities for improvement (U.K Department of Trade and Industry, 2006).

One of the excellent tools to measure efficiency of business processes is Data Envelopment Analysis (DEA). DEA has been widely applied to perform efficiency analysis in many sectors including banks, university, hotel, power plant, and hospital etc (Schaffnit, Rosen, Paradi, 1997; Pestana Barros, 2005; Johnes, 2006; Sommersguter- Reichmann, 2006; Ballesteroa & Maldonado, 2004; Cooka & Green, 2005). DEA is a technique of analyzing the efficiency of the organization using linear programming. In DEA, the organization under study is called the DMU (Decision Making unit). DMU refer to the collection of private firms, non-profit organizations, departments, administrative units, and groups with the same (or similar) goals, functions, standards and market segments. A DMU is regarded as the entity responsible for converting inputs into outputs and DEA measures the efficiency of the conversion process. Rather than the conventional one input to one output, DEA evaluates multiple inputs and multiple output systems on the basis of what is most excellent in the efficiency value. The DMU is most efficient if the efficiency obtains a score of one and is inefficient if the score is less than one. Therefore, for every DEA calculation, the objective is to maximize the value of the efficiency.

Meanwhile, Overall Equipment Effectiveness (OEE) is a key measurement of TPM. It indicates how effective the machines are running. OEE breaks the performance of a machine into three separate but measurable components: Performance Rate (PR), Quality Rate (QR) and Availability (A). Tracking OEE regularly can spot the patterns and influences that cause problems for the machines. Furthermore, measuring OEE can show us the result of our efforts to help the machines perform better. (The productivity Development Team, 2004). This paper applies DEA to measure the efficiency of measurable components of OEE for the activity that had been conducted in six periods. The objectives of this paper are to observe performance trends of the activity over time sequence and to determine the best performing period. This paper is organized as follows; Section two describes the general knowledge about Data Envelopment Analysis. Section three applies DEA to measure the efficiency of measurable components of OEE in six periods. Finally, we

conclude our work in section four.

II. DATA ENVELOPMENT ANAYSIS

DEA is a technique of analyzing the efficiency of the organization using linear programming.

Let,

j : number of DMU being compared in the DEA analysis DMU_j : DMU number j

DMU_0 : target DMU

θ: efficiency rating of the DMU being evaluated by DEA

y_{rj} : amount of output r used by DMU_j

x_{ij} : amount of input i used by DMU_j

i : number of inputs used by the DMU

r : number of outputs generated by the DMU

u_r : coefficient or weight assigned by DEA to output r v_i : coefficient or weight assigned by DEA to input i

where,

j=1,2,..,n , r=1,2,…,s , i=1,2,…,m

The DEA efficiency measure for a DMU j is given by a ratio of weighted sum of outputs to weighted sum of inputs:

$$\theta_j = \frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \qquad (1)$$

Formally, the DEA efficiency measure for a target DMU_0 is formulized by the following fractional programming.

$$\max \theta_o = \frac{\sum_{r=1}^{s} u_r y_{ro}}{\sum_{i=1}^{m} v_i x_{io}} \qquad (2)$$

subject to

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1 \ (j=1,\ldots n)$$

$$u_1, u_2, \ldots, u_s \ge 0 \ , \ v_1, v_2, \ldots, v_m \ge 0$$

Replace above fractional programming by the following linear programming,

$$\text{Max } \theta \ (= \sum_{r=1}^{s} u_r y_{ro}) \qquad (3)$$

subject to

$$\text{Max } \theta_o (= \sum_{r=1}^{s} u_r y_{ro}) \qquad (3)$$

subject to

$$\sum_{i=1}^{m} v_i x_{io} = 1$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0 \quad , j = 1,2,...,n$$

$$u_r \ge 0 \ , \ r = 1,2,...,s$$

$$v_i \ge 0 \ , i = 1,2,...,m$$

A dual problem for above linear programming is formulated as,

$$\text{Min } \theta = \theta_o - \varepsilon\left(\sum s^+ + \sum s^-\right) \qquad (4)$$

subject to

$$\theta_o x_{io} - \sum_{j=1}^{n} x_{ij} \lambda_j - s_i^- = 0,$$

$$y_{ro} - \sum_{j=1}^{n} y_{rj} \lambda_j + s_r^+ = 0$$

$$\lambda_j \ge 0, \ s_r^+ \ge 0 \ (r = 1,2,...,s), s_i^- \ge 0 \ (i = 1,2,...,m)$$

where is a non-Archimedean that is defined to be smaller than real positive number while s^- and s^+ are the input and output slacks, respectively.

Window Analysis

A DEA window analysis works on the principle of moving averages (Charnes et al.,1994; Yue,1992). And is useful to detect performance trends of a unit over time. Each unit in a different period is treated as if it was a different unit. In doing so, the performance of a unit in a particular period is contrasted with its own performance in the other periods in addition to the performance of other units.

In this method, consider N DMU's (n=1,...,N) which are observed in T periods (t=1,...,T) and which all use r inputs to produce s outputs. The sample thus has N X T observations. The whole set of time periods, T, is divided into 'windows' or sub periods. DMUs whereby the width of each window, p, is always equal. In the first assessment, the window consists of n DMUs within the time period of (1,...,p). The second window then has periods of (2,...,p+1) and this goes on to the last period (T-p+1,...,T).

PERFORMANCE MEASUREMENT OF OEE USING DEA

Mansor et.al., (2008) proposed a general model of DEA to measure maintenance activity performance by identified the general input and output based on typical input for production system and TPM measurement indices. This model could measure maintenance performance in aggregate because the model includes all the considerable resources (input) used in maintenance activities against all the considerable outcomes (output) but requires many data and takes real effort and time and cost for small and medium enterprises. Therefore, in this paper, we use a simplest model for maintenance; A model with number of maintenance personnel, maintenance cost and number of machines as the input data and quality rate (QR), availability (A), and performance rate (PR) as the output. Assumed that the are no changes for input, we used 1 ad the dummy input and the values for the output is shown in Table 1.

Table 1: Input and output data

i/o data / Period	(I)resources	(O)QR	(O) A	(O)PR
t_1	1	89.79	90.52	91.37
t_2	1	90.63	88.73	90.47
t_3	1	91.48	89.63	91.78
t_4	1	94.85	88.53	97.94
t_5	1	95.61	89.17	98.83
t_6	1	96.82	93.09	96.21

We calculated the data in Table 1 using Windows analysis with the length of window is 2 and the result is shown in Table 2. Next, we measure the efficiency of the same data in Table 1 to determine the best-performing period using CCR model, the most basic form of the DEA. We treated data for each period as an independent DMU, for example, t_1 as DMU1, t_2 as DMU2 and so on. The measured result is illustrated in graphs as shown in Figure 3.

Table 2: Results

	t_1	t_2	t_3	t_4	t_5	t_6	Average through window
	1	1					1
		0.9907	1				0.9954
			1	1			1
				0.9928	1		0.9964
					1	1	1
Average by term	1	0.9954	1	0.9964	1	1	

Variation through Window

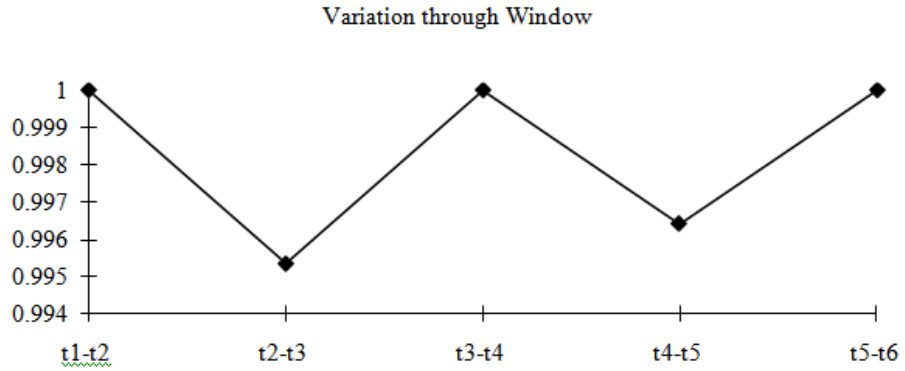

Figure 1: Variation through Window

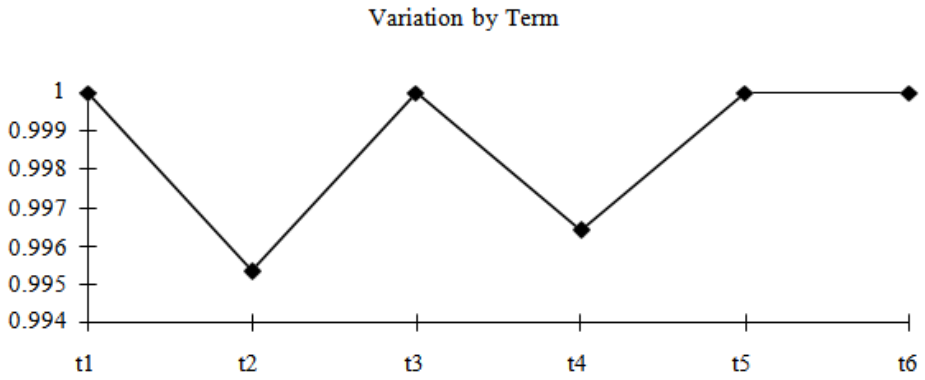

Figure 2: Variation by term

Table 3. Score and rank for each DMUs

DMU	Score	Rank
t_1	0.9724	4
t_2	0.9532	6
t_3	0.9628	5
t_4	0.9917	3
t_5	1	1

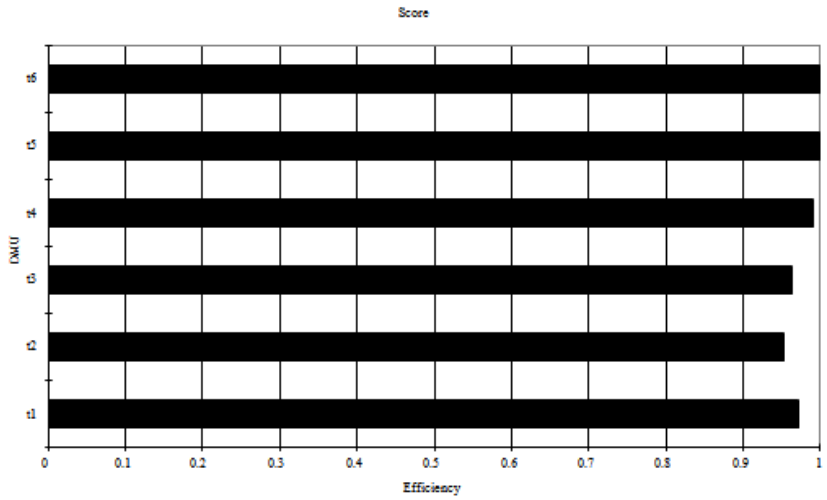

Figure 3: Score for each DMUs

III. CONCLUSIONS AND DISCUSSION

Figure 1 and Figure 2 show the trends of performance where the efficiency of the activity was not constant. Figure 3 indicates that t_5 and t_6 are the best-performing periods while the efficiency of the activity in t_2 was decreased from t_1 but keeps increasing from t_3. The management could this information to investigate why t_2 was less efficient in comparing with the others. We have presented how enterprises can use DEA method to measure or evaluate their maintenance activities as additional measurement method to OEE. In this assessment, the inputs and outputs are the most important parameter in assessing the organization though the identification of the inputs and outputs is as difficult as it is crucial. Without proper data, this method could not be applied and it will take a certain period to manage and identify the necessary data if our data are not well managed.

The efficiency of the entire organization can be assessed easily by certain indices such as yearly profit but quite difficult for the efficiency of part of organization. However, the efficiency of certain parts or functions of organization such as maintenance will also contribute to the efficiency of an entire organization. Therefore, the efficiency of certain parts or functions of an organization is something that we cannot ignore. DEA is said to be comparative or relative efficiency measurement because it requires reference to some other set of

units to compare against. Selection of reference sets is another important decision that managers should aware and taken into accounts. This might be the first thing that should be decided before proceed with the rest of the tasks. Results obtained from this assessment may be used to understand the tendency of process and derive useful information that may help the organization to make further improvements in efficiency. We believed that the reasons why DEA is not popular in maintenance area are because due to difficulty to identify the input and output and lack of data to compare with.

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