Measuring Efficiency of Teaching Hospitals in Malaysia

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Abstract

This study uses Data Envelopment Analysis, constant return to scale, input oriented to examine technical efficiency among three teaching hospitals in Malaysia. Variables of this study categorized two output and input; Outputs of the study includes number of discharged inpatient and number of visited outpatient by each department. Inputs of this study include bed, doctor, nurse and nonmedical staff. Results show that 87.5 percent of the selected clinical departments are operated inefficiently.

Keywords: Technical efficiency, Hospital efficiency, Data Envelopment Analysis

1. Introduction

Measuring of hospital efficiency plays an important and significant role in the evaluation of health policy initiatives and comparative analyses of health systems (Biørn *et al*, 2003; Gerdtham *et al*, 1999). In health care systems, the measurement of efficiency is usually the first step in auditing individual performance of production units, e.g. hospitals, health centers, *etc*. It constitutes the rational framework for the distribution of human and other resources between and within health care facilities (Kontodimopoulos *et al*, 2006).

Hospital efficiency has been the subject of numerous health economics studies. Efficiency scores have been derived using information on inputs and outputs used in the hospital's production process. It is important for hospital managers to identify the level of clinical departments' efficiency.

This study's focus is to explore the technical efficiency of clinical department among three teaching hospitals in Malaysia using the Data Envelopment Analysis (DEA) technique.

The main objective of this paper is to measure technical efficiency among clinical departments and the magnitudes of input reductions needed to make inefficient departments efficient.

This paper is structured as follow: In section 2 we discuss measuring efficiency as background, in third section the methodology used to calculate efficiency score is described, result is presented in next section and final sections provide discussion and conclusion.

2. Methodology

2.1 Measuring Efficiency

According to Aday et al (1998) efficiency is defined as Pareto optimal allocation resources. To be Pareto efficient, the production system cannot be recognized to increase the units of production without decreasing the production of other units. Efficiency is used widely in economics and refers to the best use of resources in production (Aday *et al*, 1998). Debru (1951) first measured efficiency whereas Farrell (1957) who defined a simple measure of firm efficiency that could account for multiple inputs within the context of technical, allocative and productive efficiency (Debru, 1951; Farrel, 1957). In this approach, Farrell (1957) proposed that the efficiency of any given firm consisted of two components: technical efficiency, or the ability of a firm to maximize output from a given set of inputs, and allocative efficiency, or the ability of a firm to use these inputs in optimal proportions, given the respective prices. Combining the two measures provides the measure of productive efficiency.

Recent academic research on measuring efficiency in various areas has shifted to frontier efficiency. Frontier efficiency measures deviations in performance from that of best practice firms on the efficient frontier. In general there are two main approaches:

A nonparametric piecewise-linear convex isoquant constructed such that no observed point should lie to the left or below it (known as the mathematical programming approach to the construction of frontiers); or

A parametric function, such as the Cobb-Douglas or translog form, fitted to the data, again such that no observed point should lie to the left or below it (known as the econometric approach).

These methodologies estimate a best practice frontier with the efficiency of specific decision making unit measured relative to the frontier. The frontier efficiency of a firm measures how well that firm performs relative to the predicted performance of the best firms in the industry market conditions (Cummins & Zi, 1998).

This study chose to use mathematical method (DEA) rather than parametric method (SFA) for the following reasons: DEA can handle multiple inputs and multiple outputs; it does not require an assumption of a functional form relating inputs and outputs; decision making unit are directly compared against a peer or combination of peers; and inputs and outputs can have very different units of measurement (Kahraman & Toga, 1998). According to Sherman (1986), who wrote one of the founding articles on efficiency utilizing the DEA methodology on US hospitals, DEA is a useful tool for evaluating resource among health care organizations, which can lead to improved hospital efficiency and possible reduction in actual health care cost.

2.2 Data sources

Data for this study were from Malaysian teaching hospitals (medical record and human resource departments). Data were collected from 1998 till 2006.

2.3 Variables

According to Ozcan (1992) the selection of particular input and output variables could create sensitivity in the results of efficiency variables. Input measures most frequently used were capital, labor. Inpatient discharge and outpatient visits were mostly used as output variables.

Data used in this study categorized into two parts: output and input variables. Output variables are named as inpatient discharged from the clinical department and number of outpatient visited in each clinical department, and input variables are number of bed, number of doctor, number of nurse and number of non medical staff.

2.4 The unit of analysis

In this study DMU- the unit of analysis is called decision making unit- is clinical department units. The structure of hospitals including three main departments: Administrative and technical support, ancillary service and clinical departments. We choose each clinical department as a single DMU, but when we interpret measure of efficiency at department level, however we take into account that the performance of each department will depend on the performance of two departments as mentioned above.

2.5 Data Envelopment Analysis

In 1978, Charnes *et al* first introduced DEA to evaluate the relative efficiency to comparable components of an organization. Data envelopment analysis is a technique in which linear programming is used to search for optimal combinations of inputs and outputs, based on the actual performances. DEA evaluates the technical efficiency of each DMU relative to optimal patterns of production, while patterns are computed using the performance of DMU whose inputs and outputs are not optimized by those of any other comparison or peer DMU. DEA compute the relative efficiencies with which DMUs combine major categories of inputs to generate general categories of outputs typically produced by hospitals. DEA also calculates inefficiency values for each DMU. The inefficiencies represent the degree of deviance from the frontier. Input inefficiencies show the degree to which inputs must be reduced for the inefficient DMU to lie on the best practice frontier, while output inefficiencies represent the needed increase in outputs for the DMU to become efficient.

There are various types of DEA models which may be used. The type of DEA model for this study is considered based on classical assumption of DEA model (Constant Return to Scale and Input orientation).

According to Farrell DEA generalizes single input and single-output technical efficiency measure to the multiple-input and multiple-output case. It was first introduced into the literature in 1978 by Charnes et al. as a unique unit of analysis DEA is a decision-making tool that allows for measuring the efficiency of each decision-making unit (DMU) relative to all other DMUs in a sample. The efficiency score in the presence of multiple input and output factors is defined as: Maximizing = (weighted sum of outputs/weighted sum of inputs); subject to constraints.

Assume that a DMU desires to assess the relative efficiencies of some set of comparable subunits. Further assume that management believes that the production frontier represents a function that exhibits constant returns to scale. For each DMU, there is a vector of associated inputs and outputs of managerial interest. (Determining an appropriate set of outputs and inputs is critical and requires much care). With these assumptions in place, one may formulate the following fractional programming problem that may be solved to determine technical efficiency, defined as the ratio of weighted outputs to weighted inputs, for each separate DMU:

Maximize Efficiency for DMU0= $\theta = \sum u_r \; y_{r\,j0}$

Subject to : $\sum u_r y_{rj} - \sum v_j \, x_{ij} \leq 0$

$\sum v_j \, x_{i\,j0} = 1$

$u, v \geq 0$

Where

y_{rj} = the amount of output r produced by department j,

$x_{i\,j}$ = the amount of input i used by department j,

u_r = the weight given to output r, (r = 1, … , t and t is the number of outputs)

v_i = the weight given to input i, (i = 1, … , m and m is the number of inputs)

n = the number of department,

j0 = the department under assessment

From a technical perspective, DEA evaluates inputs (bed, medical and non medical staff) in relation to output (inpatient and outpatient). The performance is indicated by a DEA score between 0 lowest possible score and 1 highest score. The DEA score provides a single indicator of organizational efficiency. A DEA sore of 1 indicates that the efficiency frontier whereas the DEA score 0.50 indicates 50 percent efficiency.

3. Result

Table1 presents means and standard deviations for input and output variables of three teaching hospitals.

Technical efficiency scores from 1998 to 2006 of 24 clinical departments can be found in Table 2. In the last column of this table, the arithmetic average of efficiency score is presented. Hospital names are replaced by A, B, C and clinical departments name are replaced by 1,2,3,.. .

Out of 24 clinical departments included in the analysis, 3 (12.5%) were technically efficient, whilst the remaining 21 (87.5%) were technically inefficient. Among the inefficient hospitals, 2 (9.5%) had a technical efficiency score between 51 and 60%, 1(4.8%) between 61 and 70%, 4 (19%) between 71 and 80%, 5 (24%) between 81 and 90%, and 8 (38%) between 91 and 99%.

The average efficiency score of hospital A, B and C were 76, 92.7, and 91.1 percent respectively. DEA has demonstrated that 87.5 percent of clinical department are run inefficiently; and they need to either reduce their inputs or increase their outputs in order to become efficient. Because in study has focused on input orientation total input reductions needed to make inefficient department efficient are presented in Table 3.

Table 3 provides the magnitudes by which specific inputs per inefficient clinical department ought to be reduced.

4. Discussion and Conclusion

This study is the first study has attempted to measure technical efficiency among clinical department in Malaysia.

DEA has been applied to the analysis of technical efficiency of clinical department in three teaching hospitals in Malaysia. It is important to recall that efficiency scores range from 0 (totally inefficient) to 1 (100% TE). The mean of efficiency score in Hospital A was 76 percent. One department was around 50 percent and six departments were more than 50 and less than 90 percent and three departments were more than 90 percent. The mean of efficiency in Hospital 2 was 92 percent. In hospital B, 2 departments were less than 90 percent and two departments had efficiency score equal 100 percent during study period. In Hospital 3 all departments were more than 75 percent and 1 department had efficiency score equals 100 percent

Efficient departments are using less input to produce more outputs compared to inefficient peers. On average, inefficient department utilized larger numbers of inputs. Even with their excess inputs, however, inefficient hospitals produced less output than their relatively efficient counterparts. The inefficient units can achieve the same level of efficiency as the efficient units by altering their inputs (including bed, doctor, nurses and non-medical staff). The optimization can be achieved through proper allocations resources. However, this critical decision has to be made in conjunction with maintaining a reasonable level of quality in these departments. In other words, the resource reallocation to achieve high efficiency should not be at the risk of lowering the quality of care. Armed with this information, the policymakers and health care managers could proactively improve efficiency in health services delivery.

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Table 1. Mean and standard deviation for inputs and outputs

	mean	**St. dev**	**max**	**min**
Hospital A				
Input bed	51.2	32.12	111	2
Input doctor	14.12	6.42	26	1
Input number of nurse	7.33	8.12	31	1
Input non medical staff	12	5.3	19	1
Output discharged inpatient	2249.94	2216.6	8635	8
Output visited outpatient	7304.57	5010.5	18553	46
Hospital B				
Input bed	87.05	41.27	136	28
Input doctor	17.92	10.03	39	4
Input nurse	11.31	5.73	28	2
Input non medical staff	21	7.08	29	2
Output discharged inpatient	3938.49	2577.45	9078	931
Output visited outpatient	31512.18	10608.87	56881	16333
Hospital C				
Input bed	84.04	44.72	181	46
Input doctor	21.2	8.61	40	8
Input nurse	11.03	10.13	43	1
Input non medical staff	11.31	6.21	25	2
Output discharged inpatient	4127.56	2541.37	8576	509
Output visited outpatient	21846.8	8062.32	36642	7472

Table 2. Efficiency score and arithmetic average among clinical department in teaching hospitals

	1998	1999	2000	2001	2002	2003	2004	2005	2006	average
A_1	45.7	46.3	46.4	46.7	46.6	49.2	54.4	57.6	59.6	50.3
A_2	44.2	49.8	53.8	48.1	55.6	56.9	57.5	62.7	66.8	55
A_3	86.9	88.3	86.3	84.3	88.7	91.5	96.1	95.4	96.1	90.4
A_4	79.6	83.8	85.4	87.4	85.4	82.2	88.4	85.6	89.9	85.3
A_5	96	96.3	97.1	96.2	95.3	97.1	97.5	97.7	98.8	96.9
A_6	70.9	74	75.4	75.9	76.4	79.4	76.1	79.3	80.2	76.4
A_7	90.6	87.7	87.7	88.5	92.8	90.5	90.8	97.6	95.6	91.3
A_8	76.7	77.8	79.9	83.8	86.9	89.9	84.9	85.9	90.2	84
A_9	63.3	64.3	65.5	63.4	63.2	66.7	65.5	66.7	70.9	65.5
A_10	59.5	61.2	60.3	61.3	64.8	65.8	64.5	68.5	75.1	64.6
B_1	88.1	87.7	87.3	88.1	88.5	88.9	89.8	90.1	90.7	88.8
B_2	89.3	89.7	90.5	90.3	94.3	95.2	95.1	94.3	95.6	92.7
B_3	100	100	100	100	100	100	100	100	100	100
B_4	93.9	90.6	92.4	94.3	97	98.6	96.7	97.4	98.6	95.5
B_5	93.5	92.2	91.8	91.9	91.4	89.9	92.9	90.9	90.8	91.7
B_6	76.8	76.3	77.5	72	75.8	71.8	73.7	76.9	73.9	75
B_7	91	94.5	100	100	97.6	100	100	98.9	99.1	97.9
B_8	100	100	100	100	100	100	100	100	100	100
C_1	78.6	79.5	78.6	79.5	82.3	86.9	89.8	94.5	97.2	85.2
C_2	81.4	81.3	85.4	88.6	89.4	95.6	94.7	97.3	95.3	89.9
C_3	82.1	82.3	84.5	85.8	89.6	87.8	87.6	89.9	97.3	87.4
C_4	100	100	100	100	100	100	100	100	100	100
C_5	92	91.1	90.3	93.7	93.1	97.5	98.5	98.3	98.7	94.8
C_6	85.8	87.3	89.4	89.6	90.6	91.1	90.5	90.9	92.1	89.7

Table 3. Total input reduction need to make individual inefficient clinic efficient

	beds	doctors	nurses	nonmedical staf
A_1	16	5	1	1
A_2	1	1	1	1
A_3	4	2	1	1
A_4	10	4	3	2
A_5	8	6	4	1
A_6	8	1	1	1
A_7	6	3	3	1
A_8	6	3	2	1
A_9	5	4	1	1
A_10	15	6	6	2
B_1	9	6	8	2
B_2	9	3	2	2
B_3	0	0	0	0
B_4	10	3	5	2
B_5	13	6	4	2
B_6	10	3	2	2
B_7	11	4	2	2
B_8	0	0	0	0
C_1	8	3	1	1
C_2	13	6	6	2
C_3	7	9	4	3
C_4	0	0	0	0
C_5	8	4	1	1
C_6	11	3	1	1