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Examining the Efficiency of Selected Private Hospitals in Southern Philippines using Data Envelopment Analysis

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Abstract

Objectives: This study aims to evaluate the relative efficiency of selected private hospitals in Southern Philippines using the output-oriented CCR model of data envelopment analysis (DEA). **Methods:** The output-oriented CCR model of the DEA is applied to analyze efficiency of selected private hospitals in the Philippines using four inputs (namely, doctors, nurses, other staffs and beds) and four outputs (namely, minor operations, major operations, cases treated and patient days) as parameters. **Findings:** DEA is a management tool commonly used to evaluate the efficiency of service units referred to as the decision-making units (DMUs) working under similar conditions and using the same types of inputs to produce the same kind of output. Unlike typical statistical approaches which compare productivity of a unit with respect to the average, DEA compares each unit with the best units and are classified as either efficient or less efficient. Moreover, the less efficient DMUs need to adopt its efficiency reference set (ERS) or benchmarks for it to improve and become efficient. Results of the study show that 1 out of 10 private hospitals are found to be less efficient using CCR model. Results further provide the magnitude of efficiency of each DMU and also reveal the potential improvements for the private hospital identified as less efficient using the model, on the basis of quantifying the efficiency. **Application:** This study can provide a way for the hospitals to better enhance their efficiency.

Keywords: Data Envelopment Analysis, Efficiency, Private Hospitals

1. Introduction

Hospitals need to provide services appropriate to the health needs of the population(s) they are serving[1]. They have the mandate to provide appropriate care and services that can be accessed by all members of the community. Its purpose includes the delivery of the best health care to their patients, providing the health needs of local people, delivering high quality care in a responsive way, enabling staff to develop their individual expertise and to work with pride, and fostering the commitment and loyalty of the community.

In the Philippines, the Department of Health (DOH) is the executive department of the Philippine government responsible for ensuring access to promote good health and improving the quality of basic medications. It is the chief formulator of Philippine health care systems. The mission of DOH is to provide quality health care with sustainable financing and improved health-seeking behaviours that is equitably accessible to all and lays the foundation for healthy living and service for the common good. DOH provides the people with proper medications and treatments they need to help them to become healthy and productive citizens.

Due to the vital role that hospitals play in the society, there is a great need to ensure efficiency among hospitals. Data envelopment analysis (DEA) was first introduced by Charnes, Cooper and Rhodes in 1978. It is a linear

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programming-based technique for evaluating the performance of administrative units. Decision-making units (DMUs) to which DEA has been applied are banks, mutual funds, police stations, hospitals, tax offices, defence bases, insurance companies, schools, libraries and university departments[2]. Unlike other statistical techniques, DEA can handle multiple inputs and multiple outputs. It also evaluates the relative efficiency of the present set of units and provides an analysis of how these inputs and outputs will have to be changed in order to maximize the efficiency of the target DMU[3]. In DEA, the distance of every DMU to the efficient frontier is measured and expressed in the form of efficiency score[4].

To be able to assess hospital performance, the Charles, Cooper and Rhodes (CCR) model[5] is used in this study. Since hospitals have to provide maximum provision of services from fixed amounts of resources, this study uses the output-oriented CCR model with the proper selection of inputs and outputs factors to determine how good of a discrimination exists between efficient and inefficient units.

In this paper, the relative efficiency of selected private hospitals in the Philippines are evaluated using the output-oriented CCR DEA model in order to determine which of the hospitals are most efficient, to identify the magnitude of less efficiency, and to point out specific less efficiency of other hospitals. This study only covers ten (10) private hospitals which serves as the DMUs, namely Puerto Community Hospitals (PCH), Sabal Hospital Inc., Maria Reyna Xavier University - Ateneo de Cagayan Hospital, Capitol University Medical Centre (CUMC), Cagayan de Oro Maternity and Children's Hospital, Cagayan de Oro Poly medic General Hospital, Madonna and Child Hospital, Cagayan de Oro Poly medic Plaza, Tag loan Poly medic General Hospital and Phillips Memorial Hospital. However, these hospitals shall be coded in order not to reveal their identities in relation to the assessment results. Moreover, this study only considers data covering the year 2009 to 2013. This paper is organized as follows. A brief introduction is given in Section 1. Section 2 provides the methodology. Section 3 presents and discussed the results of this study and Section 4 provides a brief conclusion.

2. Methodologies

In order to apply DEA in examining the efficiency of private hospitals, we need the actual observed outputs produced Y_{jk} and the actual inputs used X_{ik}, during one-time period for each of the 10 private hospitals considered in this study. Data used in this study cover the period 2009 to 2013 and were taken from the human resource office of the ten private hospitals. Table 1 shows the input and output parameters considered in this study.

Table 1. Input and output parameters used in this study

	Input Parameters (i)	Output Parameters (j)
1	Human Resources	Operations and Cases Treated
2	Beds	Patient Days

Table 2. Average input data parameters

DMU Name/ Private Hospital	Input	
	1	2
	Human Resource	Beds
A	227	83
B	94	35
C	112	70
D	216	250
E	179	105
F	386	114
G	347	262
H	308	133
I	56	50
J	76	133
Average	199	123

Table 3. Average output data parameters

DMU Name / Private Hospital	Output	
	1	2
	Operations and Cases Treated	Patient Days
A	19794	5746
B	7478	5402
C	9857	1231
D	3634	6581
E	17709	5691
F	24663	9260

G	21645	8029
H	10717	6806
I	5076	2831
J	7185	5564
Average	12774	5714

The private hospitals with their corresponding inputs and outputs are shown in Table 2,3, respectively. As shown in Table 2, Hospital F has the largest number of inputs in human resources (including doctors and nurses) while hospital G has the most number of beds. Hospital I has the least number of human resources while hospital B has the least number of beds. It can be seen from Table 3 that Hospital F also has the largest number of all outputs in both operations and cases treated and patient days. On the other hand, Private Hospital I has the least number of operations and cases treated while hospital I has the least patient days.

In DEA, efficiency is evaluated by computing the ratio of outputs to inputs. Hence, the higher output observed per unit of input correspond to a relatively greater efficiency. In order to assess the efficiency of the private hospitals, we let

Θ = be the efficiency score for DMU k

Y_{jk} = be the average value of output j for DMU k

X_{ik} = be the average value of input i for DMU k

v_i = be the coefficient/weighted input assigned by DEA

u_k = be the coefficient/weighted output assigned by DEA

λ_k = be the weights of the DMUs

i = 1, 2 represents the 2 input parameters

j = 1, 2 represents the 2 output parameters

k = A, B, …, K represents the 10 hospitals or the DMUs

The following equation shows the Output-Oriented CCR model.

$$\text{Minimize } \Theta = \left[\frac{\left(\sum_{j=1}^{2} u_j Y_{jk}\right)}{\left(\sum_{i=1}^{2} v_i X_{ik}\right)}\right] \quad (1)$$

$$\text{Subject to } \left[\frac{\left(\sum_{j=1}^{2} u_j Y_{jk}\right)}{\left(\sum_{i=1}^{2} v_i X_{ik}\right)}\right] \leq 1 \quad (a)$$

$$\sum_{k=1}^{10} \lambda_k X_{ik} \leq \Theta X_{i0} \; i = 1,2 \quad (b)$$

$$\sum_{k=1}^{10} \lambda_k Y_{jk} \geq Y_{k0} \quad j = 1,2 \quad (c)$$

$$\lambda_k \geq 0 u_j, v_i \geq \varepsilon \quad , \quad \varepsilon > 0$$

When using DEA, it should be noted that the sets of inputs and outputs are converted to a single virtual input and a single virtual outputthrough the introduction of weights u_k and v_i. The ratio of the virtual output to the virtual input is then computed in order todetermine the efficiency associated with each of the private hospitals. Moreover, the weights are determined in such a way that its virtual input is set equal to 1. The resulting virtual output for that DMU determines its relative efficiency. Constraint (a) ensures that no DMU has efficiency greater than 1. The weights are then obtained by solving the constraints (a) to (c), and the other service units with non-zero weight values are the units in the efficiency reference set (ERS).

If the value of the efficiency rating for the private hospital being evaluated, denoted by Θ, is less than 100%, then that specific hospital is considered to beless efficient. This means that this hospital has the potential to produce the same or more level of output with fewer inputs.

Microsoft® Excel spreadsheet (Excel) solver software was used to solve the LP model (1) in order to determine the relative efficiency of ten private hospitals based on CCR output-oriented model. Results will also provide information on how the less efficient hospitals can be potentially improved.

Table 4. The CCR Model Efficiency Score Results

DMU Name / Private Hospitals	CCR Efficiency Score (%)
A	100
B	100
C	71.55
D	25.92
E	33.33
F	32.75
G	18.07
H	28.32
I	100
J	100

3. Results and Discussion

Table 4 shows the CCR efficiency scores for each private hospital. The hospitals which obtained efficiency rating of 100% comprise the best practice set. Among the ten private hospitals examined, only 4 hospitals, namely hospital A, B, I and J, obtained an efficiency rating of 100%. Hence, only these 4 hospitals are considered efficient based on the CCR model. On the other hand, hospitals C, D, E, F, G, and H are found to be less efficient. This could be attributed to the fact that although most of these hospitals have the most number of inputs, they also have below average outputs.

Table 5. The efficiency reference set (ERS) of DMU C using CCR model

DMU	ERS
A	0
B	0.3347
C	0
D	0
E	0.0929
F	0
G	0
H	0
I	0.5725
J	0

Table 6. The efficiency reference set (ERS) of DMU D using CCR model

DMU	ERS
A	0
B	0
C	0
D	0
E	0
F	0
G	0
H	0
I	1
J	0

Table 7. The efficiency reference set (ERS) of DMU E using CCR model

DMU	ERS
A	0
B	1
C	0
D	0
E	0
F	0
G	0
H	0
I	0
J	0

Table 8. The efficiency reference set (ERS) of DMU F using CCR model

DMU	ERS
A	0.0487
B	0.9513
C	0
D	0
E	0
F	0
G	0
H	0
I	0
J	0

Table 9. The efficiency reference set (ERS) of DMU G using CCR model

DMU	ERS
A	0
B	0.1766
C	0
D	0
E	0
F	0
G	0
H	0
I	0.8234
J	0

Table 10. The efficiency reference set (ERS) of DMU H using CCR model

DMU	ERS
A	0
B	0.8220
C	0
D	0
E	0
F	0
G	0
H	0
I	0.1780
J	0

	DMU B		DMU E		DMU I		DMU C
	94		179		56		80
(0.3347)	35	+(0.0929)	105	+(0.5725)	50	=	50
	7478		17709		5076		7053
	5402		5691		2831		3957

Figure 1. Composite values for hospital C.

	DMU I		DMU D
	56		56
	50		50
(1)	5076	=	5076
	2831		2831

Figure 2. Composite values for hospital D.

	DMU B		DMU E
	94		94
	35		35
(1)	7478	=	7478
	5402		5402

Figure 3. Composite values for hospital E.

	DMU A		DMU B		DMU F
	227		94		100
(0.0487)	83	+(0.9513)	35	=	37
	19794		7478		8077
	5746		5402		5419

Figure 4. Composite values for hospital F.

	DMU B		DMU I		DMU G
	94		56		63
(0.1766)	35	+(0.8234)	50	=	47
	7478		5076		5500
	5402		2831		3285

Figure 5. Composite values for hospital G.

	DMU A		DMU B		DMU F
	94		56		87
(0.8220)	35	+(0.1780)	50	=	38
	7478		5076		7050
	5402		2831		4944

Figure 6. Composite values for hospital H.

	Actual	-	Composite	=	Excess	Remarks
Human Resource	112		80		32	Exceed
Beds	70		50		20	Exceed
Operations and Cases Treated	9857		7053		2804	Exceed
Patient Days	1231		3957		-2726	Less Output Achieved

Figure 7. The efficiency reference set of DMU.

In order to determine as to what should be the ideal number of inputs and outputs that will help improve the efficiency of the less efficient hospitals, it is necessary to compute for the composite values or the values of inputs that could make the less efficient private hospitals produce more favourable outputs. Tables 5-10 show the ERS or benchmarks for these hospitals. These ERS weights indicate how the relatively efficient private hospitals fare against the less efficient private hospitals. Figures 1-6 show the composite values for the less efficient hospitals C, D, E, F, G and H. Moreover, Figures 7-12 suggest a mixture of the operating techniques that should be utilized by the less efficient hospitals that would result in

composite hypothetical private hospitals that processes more of outputs but require lesser inputs that what they currently have. In particular, Figures 1 and 7 shows how hospital C can become efficient in comparison to hospitals B, E and I. That is, hospital C should be able to reduce human resources by 32 and beds by 20 in order to achieve efficiency.

	Actual	-	Composite	=	Excess	Remarks
Human Resource	216		56		160	Exceed
Beds	250		50		200	Exceed
Operations and Cases Treated	3634		5076		-1442	Less Output Achieved
Patient Days	6581		2831		3750	Exceed

Figure 8. The efficiency reference set of DMU D.

	Actual	-	Composite	=	Excess	Remarks
Human Resource	179		94		85	Exceed
Beds	105		35		70	Exceed
Operations and Cases Treated	17709		7478		10231	Exceed
Patient Days	5691		5402		289	Exceed

Figure 9. The efficiency reference set of DMU E.

	Actual	-	Composite	=	Excess	Remarks
Human Resource	386		100		286	Exceed
Beds	114		37		77	Exceed
Operations and Cases Treated	24663		8077		16586	Exceed
Patient Days	9260		5419		3841	Exceed

Figure 10. The efficiency reference set of DMU F.

Human Resource	347		63		315	Exceed
Beds	262		47		215	Exceed
Operations and Cases Treated	21645		5500		16145	Exceed
Patient Days	8029		3285		4744	Exceed

Figure 11. The efficiency reference set of DMU G.

	Actual	-	Composite	=	Excess	Remarks
Human Resource	308		87		221	Exceed
Beds	133		38		95	Exceed
Operations and Cases Treated	10717		7050		3667	Exceed
Patient Days	6806		4944		1862	Exceed

Figure 12. The efficiency reference set of DMU H.

4. Conclusion

This study used the output minimizing data envelopment analysis approach to measure both the efficiencies of private hospitals in Cagayan de Oro City. Results of the study focused more on inputs rather than outputs. Output-oriented DEA models produce a maintaining at least the same output levels while use fewer inputs offering a path to improve efficiency of the less efficient units. The DMUs considered in this study are the ten private hospitals and the study covered the period (2009-2013). Two input and two output parameters were selected to represent these hospitals' respective efficiencies, namely, human resources and beds, and operations and cases treated and patient days, respectively.

DEA has determined that, among the ten private hospitals, only 4 private hospitals are found to be efficient while 6 are considered less efficient based on the CCR Model. Moreover, less efficient hospitals need to adopt their respective ERS or benchmarks for them to improve and become efficient. The primary advantages of this technique are that it considers multiple factors and does not require parametric assumptions of traditional multivariate methods.

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