Measuring the Relative Efficiency and Scale Efficiencyof Health Organization in Thi Qar Province Using BCC Model

Ahmed Noori Yousef, Rasheed Al-Salih, Muaamar Aqeel Obaid
University of Sumer, College of Administration and Economics, Iraq
University of Wasit, College of Administration and Economics, Iraq
ahmed.mba@uos.edu.iq,muamaraqeel.ma@gmail.com, basheerreh79@gmail.com

Abstract

In this paper, we use one of the most well-known data envelopment analysis DEA model which is presented by (Banker, Charnes, Cooper) which know as BCC model to measure the relative efficiency and scale efficiency of health organization in Thi Qar province with respect to their inputs and outputs. The case study consists of eight hospitals with four inputs and three outputs for two years period i.e., 2020 and 2021. First, we calculate the relative efficiency based on BCC model and we conclude that six hospitals get full efficiency and the relative efficiency for other hospitals is 0.80, and 0.88. Second, we calculate the scaleefficiency and we see that the minimum scale efficiency is 0.71 in 2020 while in 2021 the minimum scale efficiency is 0.80. We conclude that most of the hospital get high score efficiency during 2020 and they improve their performance during 2021 as well.

DOI Number: 10.48047/NQ.2023.21.3.NQ33030 NeuroQuantology2023;21(3): 295-302

1.Introduction

Performance evaluation plays an important role in the overall performance management process. It is exercised in the observation and judgment, a feedback process, and organizational intervention. It is a measurement process as well as an intensive emotional process. Above all, it is a fairly accurate human process. In studying the stimulation of work, there is fairly firm principle that things that get a bonus are accomplished. Therefore, managers have options. They can emphasize short or long term objectives in the performance assessment process, or a mix of both of them, short-term goals confirm things like the final results of the current quarter. The long-term goals confirm things such as increased market share and frequent business insurance from customers. In order for the strategic management to assess more useful performance, the strategies used by

the Organization (or Strategic Business Unit) must be associated with a competitive advantage - for example, innovation or innovation Speed, or improve quality, or cost control. "Some common evaluation systems in the United States, such as the management of MBO, are less common in other parts of the world, such as Japan and France. MBO is mainly focusing on the results, rather than focusing on how to achieve results, usually have a short-term focus, although this should not be always. In Japan, focus is greater on psychological and behavioral aspects of performance evaluation more than focus on substantive results, therefore, the employee will be classified in terms of the effort; on integrity and loyalty The spirit of cooperation; the quality of its service for the customer. On the other hand, not parametric linear programming approach known as data envelopment analysis DEA have used to measure the relative efficiency based on the input and output of the decision making units for more details of new formulations and applications for linear programming models and DEA models we refer for examples into [1],[2],[3],[4],[5],[6],[7].

In this work, we use the BCC model to measure the relative efficiency and scale efficiency of eight hospitals in Thiqar province based on four inputs and three outputs.

2.DEA models

1. DEA models

One of the most well-known data envelopment analysis DEA model which is presented by (Banker, Charnes, Cooper) which know as BCC model. As in [7],[8],[9],[10],[11], output- oriented BCC (BCC.O) and input- oriented BCC (BBC.I) are described as follows:

$$\text{Min } (\pi \,.\, x^{j*}) + \varepsilon \qquad \text{(BCC -O)}$$

S.t.

$$(\pi \,.x^{j}) - (\eth \,.\, y^{j}) + \varepsilon \geq 0 \quad ,j = 1 \ldots\ldots n:$$

$$(\eth .\, y^{j*}) = 1:$$

$$\Pi, \eth \geq 0 .$$

eISSN 1303-5150

$$\text{Max } (ð.y^{j*}) + ε \qquad \text{(BCC -I)}$$

S.t.

$$(ð.y^{j}) - (π.x^{j}) + ε \leq 0 \quad ,j = 1 \ldots\ldots n :$$

$$(π.x^{j*}) = 1$$

$$Π, ð \geq 0.$$

3.Case study

In this study, we consider 8 hospitals in Thiqar province as follows: Al-Hussein Teaching Hospital (HTH), Nasiriyah Heart Center (NHC), Al Haboubi General Hospital (HGH), Bint Al Huda Maternity Hospital (BHMH), Mohammed Al Mousawi Hospital (MMH), Al Rifai General Hospital (RGH), Shatrah General Hospital (SGH), Souq Al-Shuyoukh General Hospital (SSGH). Also, for each hospital, we choose four inputs and three outputs as in Table 1and Table 2, Table 3, and Table 4 respectively. The data collected for 2020 and 2021.

3.1 Input and output data

Table 1: 2020 Input data

No.	Hospital Name	No. of Employees	No. of Doctors	No. of Medical Devices	No. of hospital beds
1	HTH	5102	530	3076	400
2	NHC	1800	105	688	124
3	HGH	1990	194	597	124
4	BHMH	2153	125	1093	154
5	MMH	1202	37	257	133
6	RGH	533	104	360	169
7	SGH	1809	98	1353	169
8	SSGH	1920	102	688	285

Table 2:2020 Output data

No.	Hospital Name	No. of Medical Examinations	No. of Inpatients	No. of Patients
1	HTH	460215	10405	12948

eISSN 1303-5150

2	NHC	75163	4562	8351
3	HGH	65714	7087	52638
4	BHMH	35465	7087	42638
5	MMH	130757	9330	17615
6	RGH	140778	10988	128323
7	SGH	164015	12768	120482
8	SSGH	130691	6071	84119

Table 3: 2021 Input data

No.	Hospital Name	No. of Employees	No. of Doctors	No. of Medical Devices	No. of hospital beds
1	HTH	5089	563	3200	220
2	NHC	1606	112	680	124
3	HGH	2006	199	542	124
4	BHMH	2164	132	1102	154
5	MMH	1249	35	259	133
6	RGH	608	110	400	154
7	SGH	2222	89	1213	160
8	SSGH	1961	105	600	222

Table 4: 2021 Output data

No.	Hospital Name	No. of Medical Examinations	No. of Inpatients	No. of Patients
1	HTH	602676	10915	25356
2	NHC	132602	6322	17430
3	HGH	57952	10490	71439
4	BHMH	40663	11012	51445
5	MMH	83960	2713	23977
6	RGH	138876	14910	141431
7	SGH	172658	10564	105353
8	SSGH	127601	6322	87453

3.2 Mathematical formulation

In this section, we formulate the BCC model based on the input and output data the presented in Table 1 and Table 2 respectively.

The BCC model for (HTH) is as follows:

$$\text{Max } Z_1 = \frac{460215Y_1+10405Y_2+12948Y_3}{5102X_1+530X_2+3076X_3+400X_4}$$

S.t.

$$\frac{460215Y_1+10405Y_2+12948Y_3}{5102X_1+530X_2+3076X_3+400X_4} \leq 1$$

$$\frac{75163Y_1+4567Y_2+8351Y_3}{1800X_1+105X_2+835X_3+124X_4} \leq 1$$

$$\frac{65714Y_1+7087Y_2+52638Y_3}{1990X_1+194X_2+597X_3+124X_4} \leq 1$$

$$\frac{35465Y_1+7087Y_2+4638Y_3}{2153X_1+125X_2+1093X_3+154X_4} \leq 1$$

$$\frac{130757Y_1+9330Y_2+17615Y_3}{1202X_1+37X_2+257X_3+133X_4} \leq 1$$

$$\frac{140778Y_1+10988Y_2+128323Y_3}{533X_1+104X_2+360X_3+169X_4} \leq 1$$

$$\frac{164015Y_1+12768Y_2+120482Y_3}{1809X_1+98X_2+1353X_3+169X_4} \leq 1$$

$$\frac{130691Y_1+6071Y_2+84119Y_3}{1920X_1+102X_2+688X_3+285X_4} \leq 1$$

$$X_1, X_2, X_3, X_4, Y_1, Y_2, Y_3 \geq 0$$

Which is implies the following linear form:

$$\text{Max } Z_1 = 460215Y_1 + 10405Y_2 + 12948Y_3 + \varepsilon$$

S.t.

$$5102X_1 + 530X_2 + 3076X_3 + 400X_4 = 1$$

$$1460215Y_1 + 10405Y_2 + 12948Y_3 \leq 5102X_1 + 530X_2 + 3076X_3 + 400X_4 \rightarrow$$

$$460215Y_1 + 10405Y_2 + 12948Y_3 - 5102X_1 - 530X_2 - 3076X_3 - 400X_4 + \varepsilon \leq 0$$

$$275163Y_1 + 4567Y_2 + 8351Y_3 \leq 1800X_1 + 105X_2 + 835X_3 + 124X_4 \rightarrow$$

$$75163Y_1 + 4567Y_2 + 8351Y_3 - 1800X_1 - 105X_2 - 835X_3 - 124X_4 + \varepsilon \leq 0$$

$$65714Y_1 + 7087Y_2 + 52638Y_3 \leq 1990X_1 + 194X_2 + 597X_3 + 124X_4 \rightarrow$$

$$65714Y_1 + 7087Y_2 + 52638Y_3 - 1990X_1 - 194X_2 - 597X_3 - 124X_4 + \varepsilon \leq 0$$

$$35465Y_1 + 7087Y_2 + 4638Y_3 \leq 2153X_1 + 125X_2 + 1093X_3 + 154X_4 \rightarrow$$

eISSN 1303-5150

$35465Y_1 + 7087Y_2 + 4638Y_3$ - $2153X_1 - 125X_2 - 1093X_3 - 154X_4 + \varepsilon \leq 0$

$130757Y_1 + 9330Y_2 + 17615Y_3 \leq 1202X_1 + 37X_2 + 257X_3 + 133X_4 \rightarrow$

$130757Y_1 + 9330Y_2 + 17615Y_3$ - $1202X_1 - 37X_2 - 257X_3 - 133X_4 + \varepsilon \leq 0$

$140778Y_1 + 10988Y_2 + 128323Y_3 \leq 533X_1 + 104X_2 + 360X_3 + 169X_4 \rightarrow$

$140778Y_1 + 10988Y_2 + 128323Y_3$ - $533X_1 - 104X_2 - 360X_3 - 169X_4 + \varepsilon \leq 0$

$164015Y_1 + 12768Y_2 + 120482Y \leq 1809X_1 + 98X_2 + 1353X_3 + 169X_4 \rightarrow$

$164015Y_1 + 12768Y_2 + 120482Y_3$ - $1809X_1 - 98X_2 - 1353X_3 - 169X_4 + \varepsilon \leq 0$

$130691Y_1 + 6071Y_2 + 84119Y_3 \leq 1920X_1 + 102X_2 + 688X_3 + 285X_4 \rightarrow$

$130691Y_1 + 6071Y_2 + 84119Y_3$ - $1920X_1 - 102X_2 - 688X_3 - 285X_4 + \varepsilon \leq 0$

$X_1, X_2, X_3, X_4, Y_1, Y_2, Y_3 \geq 0$

In the similar way, we do BCC the formulation for other seven hospitals.

3.3. Results

Using DEAP solver we obtain the following results:

Table 5: BCC-2020 Hospitals Efficiency

DMUs	BCC-Efficiency	Scale Efficiency
HTH	1	1
NHC	1	0.60
HGH	1	0.80
BHMH	0.86	0.71
MMH	1	1
RGH	1	1
SGH	1	1
SSGH	0.76	0.97

Table 6: BCC- 2021 Hospitals Efficiency

DMUs	BCC-Efficiency	Scale efficiency
HTH	1	1
NHC	1	0.89

HGH	1	0.87
BHMH	0.88	0.80
MMH	1	1
RGH	1	1
SGH	1	1
SSGH	0.80	0.93

4.Conclusions

In this paper, we present the performance assessment for eight hospitals in Thiqar province using BCC model. The study shows the hospitals HTH, MMH, RGH, and SGH reach full efficiency during 2020 as well as 2021. Also, the hospital NHC gets the minimum efficiency during 2020 while the hospital BHMH gets the minimum efficiency during 2021. Moreover, the hospitals NHC, HGH, BHMH, and SSGH have improved their efficiencies through 2021. Furthermore, based on the efficient decision making units, the decision maker can improve inefficient units by reducing the inputs or increasing the outputs.

References

[1] Al-Salih, R., & Bohner, M. (2018). Linear programming problems on time scales. *Applicable Analysis and Discrete Mathematics*, *12*(1), 192-204.

[2] Al-Salih, R., & Bohner, M. J. (2020). Separated and state-constrained separated linear programming problems on time scales. *Boletim da Sociedade Paranaense de Matemática*, *38*(4), 181-195.

[3] Al-Salih, R., & Bohner, M. (2019). Linear fractional programming problems on time scales. *Journal of Numerical Mathematics and Stochastics*, *11*(1), 1-18.

[4] Al-Salih, R., Habeeb, A., & Laith, W. (2019, July). A Quantum calculus analogue of dynamic Leontief production model with linear objective function. In *Journal of Physics: Conference Series* (Vol. 1234, No. 1, p. 012102). IOP Publishing.

[5] Hamed, Q. A., Al-Salih, R., & Laith, W. (2020, May). The analogue of regional economic models in quantum calculus. In *Journal of Physics: Conference Series* (Vol. 1530, No. 1, p. 012075). IOP Publishing.

eISSN 1303-5150

[6]Lafta, M. H., Sulaiman, A. A., & Al-Salih, R. (2021, May). A Computational Procedure Using Robust Ranking Method to Formulate and Solve Fuzzy DEA Models. In *Journal of Physics: Conference Series* (Vol. 1879, No. 3, p. 032006). IOP Publishing.

[7]Bhattacharyya, A., & Chakraborty, S. (2014). A DEA-TOPSIS-based approach for performance evaluation of Indian technical institutes. *Decision science letters*, *3*(3), 397-410

[8]Rakhshan, S. A. (2017). Efficiency ranking of decision making units in data envelopment analysis by using TOPSIS-DEA method. *Journal of the Operational Research Society*, *68*(8), 906-918.

[9]Peng, C., Feng, D., & Guo, S. (2021). Material selection in green design: a method combining DEA and TOPSIS. *Sustainability*, *13*(10), 5497.

[10]Ghasemi, S., Aghsami, A., & Rabbani, M. (2020). Data envelopment analysis for estimate efficiency and ranking operating rooms: a case study. *Int J Res Ind Eng*, *10*(1), 67-86.

[11] Battal, Ahmad et al. (2017).Data envelopment analysis: theory and applications. Noor Publishing.