Biomedical Statistics and Informatics
2016; 1(1): 19-23
http://www.sciencepublishinggroup.com/j/bsi
doi: 10.11648/j.bsi.20160101.13

An Empirical Investigation on the Efficiency of Healthcare Companies with Data Envelopment Analysis Model

Lam Weng Siew[1, 2], Liew Kah Fai[1, *], Lam Weng Hoe[1, 2]

[1]Department of Physical and Mathematical Science, Faculty of Science, UniversitiTunku Abdul Rahman, Kampar Campus, Kampar, Malaysia

[2]Centre for Mathematical Sciences, Centre for Business and Management, UniversitiTunku Abdul Rahman, Kampar Campus, Kampar, Malaysia

Email address:

lamws@utar.edu.my (L. W. Siew), liewkf@utar.edu.my (L. K. Fai), whlam@utar.edu.my (L. W. Hoe)

[*]Corresponding author

To cite this article:

Lam Weng Siew, Liew Kah Fai, Lam Weng Hoe. An Empirical Investigation on the Efficiency of Healthcare Companies with Data Envelopment Analysis Model. *Biomedical Statistics and Informatics.* Vol. 1, No. 1, 2016, pp. 19-23. doi: 10.11648/j.bsi.20160101.13

Received: October 24, 2016; **Accepted**: December 2, 2016; **Published**: January 7, 2017

Abstract: Healthcare service quality plays an important role in today's competitive environment. The people are very concern on their health status nowadays and willing to seek an affordable treatment from the healthcare companies. Besides affordable treatment, the people are also particular on the healthcare efficiency as the quality of the services and companies performance aresignificantly determined by the company's efficiency. Data Envelopment Analysis (DEA) is a mathematical linear programming model which is utilized for measuring the efficiency of the companies as the ratio of the sum-weighted outputs to sum-weighted inputs. The objective of this study is to evaluate and compare the efficiency of the healthcare companies in Malaysia withDEA model. In this study, the data consists of 12healthcare companies that are listed in Malaysia stock market. The period of study is from year 2011 until 2015. The results of this study show thatAHEALTH, HAIO, IHH, PHARMA and YSPSAH are ranked as efficient healthcare companies. This study is significant because the DEA model helps to identify the efficient healthcare companies based on multiple inputs and outputs.

Keywords: Healthcare Company, Data Envelopment Analysis, Efficiency, Linear Programming Model

1. Introduction

Healthcare service quality plays an important role in today's competitive environment [1, 2]. The people are concern on their health status nowadays and willing to seek an affordable treatment from the healthcare companies. Besides that, the people are also particular on the healthcare efficiency as the quality of the services and companies performance are significantly determined by the company's efficiency. Healthcare industry is responsible to provide goods and services to the consumers in order to enhance the life expectancy, quality of life, diagnostic and treatment options, efficiency and cost effectiveness of the healthcare system [3]. Efficiency is used to measure how efficient an organizational unit is performing in utilizing resources to generate outcomes or outputs. DEA model is considered as an improved alternative to the traditional ratio analysis when evaluating the performance of the entities [4]. DEA model is used to evaluate the efficiency of the decision making units (DMUs). Current ratio, debt to equity ratio, earnings per share (EPS) and return on equity (ROE) are the important inputs and outputs that needed to be considered in this study.

DEA model was developed by [5] to measure the relative efficiency of a set of decision making units (DMUs) such as companies, banks, hospitals, schools and so forth. DEA is a non-parametric technique based on the mathematical linear programming model which is capable of handling multiple inputs and outputs simultaneously. In DEA model,the performance of the unit is measured in terms of efficiency. Efficiency isthe ratio of sum-weighted outputs to sum-weighted inputs. The units that achieve an efficiency score of 100% are considered as efficient units. On the other hand, the units that failed to reach 100% efficiency will be classified as inefficient units. Furthermore, DEA model has been applied

in various areas such as banks [6], hospitals [7], healthcare industry [8], airline[9], and hotels[10]. The objective of this paperis to evaluate and compare the efficiency of the healthcare companies in Malaysia withDEA model. Therestofthepaperisorganizedasfollows. The next section describes the literature review of DEA model in the evaluation on the efficiency of healthcare companies. Section 3 discusses about the data and methodology of the study. Section 4 presents theempiricalresultsof thisstudy. Section 5 concludesthepaper.

2. Literature Review

Reference [11] have applied the DEA modelinthe evaluation on the efficiency of 30 public healthcare companies in Europe. There were total of 30 European states analyzed in their study, Austria, Belgium, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Latvia, Lithuania, Luxembourg, Malta, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, and the United Kingdom. The results of this study showed that certaindeveloped countries and developing countries were efficient in converting their inputs into outputs effectively.

Reference [12] have determined the efficiency of 34 health posts in rural Guatemala from year 2008 until 2009 by using DEA model. The number of efficient health posts were 10 and 8 in year 2008 and 2009 respectively. Reference [7] have evaluated the efficiency of 128district hospitals in Ghana in year 2005 by using the DEA model. Thetypes of hospitals were government hospitals, mission hospitals, quasi-government hospitals and private hospitals. Based on the results, 31 out of 128 district hospitals were identified as efficient hospitals. The highest efficiency score of 0.839 was obtained by the quasi-government hospitals. The public hospitals managed to achieve 0.704 efficiency score followed by mission hospitals and private hospitals, which were 0.686 and 0.558 respectively.

Reference [13] have assessed the efficiency of home health care agencies by using the DEA model. There were total of 3913 home health care agencies evaluated in their study. The results of this study showed thatmost of the home health care agencies managed to achieve efficiency scoreabove 0.70.

Based on the past research, DEA model has been applied in different fields and countriesto evaluate the efficiency of the units. However, DEA model has not been studied actively in Malaysia. Therefore, this paper aims to fill the research gap by evaluating the efficiency of the healthcare companies in Malaysia by using DEA model.

3. Data and Methodology

3.1. Data

In this study, the data consists of 12 healthcare companies which arelisted in Malaysia stock market from year 2011 until 2015 as shown in Table 1.

Table 1. *Healthcare Companies in Malaysia Stock Market.*

CompanyName	Abbreviations	Code
AdventaBerhad	ADVENTA	7191
Apex Healthcare Berhad	AHEALTH	7090
Berjaya Corporation Berhad	BJCORP	3395
DKSH Holdings (Malaysia) Berhad	DKSH	5908
Hai-O Enterprise Berhad	HAIO	7668
HovidBerhad	HOVID	7213
IHH Healthcare Berhad	IHH	5225
Kotra Industries Berhad	KOTRA	0002
KPJ Healthcare Berhad	KPJ	5878
PharmaniagaBerhad	PHARMA	7081
PeterLabs Holdings Berhad	PLABS	0171
Y.S.P.Southeast Asia Holding Berhad	YSPSAH	7178

Source: [14]

The inputs identified in this study are current ratio and debt to equity ratio. On the other hand, earnings per share (EPS) andreturn on equity (ROE) are identified as outputs.

The current ratio is the measures a company's ability to counter balance current assets with the current liabilities [15]. Debt to equity ratio is the relative proportion of shareholders' equity and debt used to finance a company's assets [16]. Earnings per share (EPS) is the monetary value of earnings per outstanding share of common stock for a company [16]. Return on equity (ROE) is the measures a company's efficiency at generating profits from every unit of shareholders' equity [17]. Table 2 presents the formula for the financial ratios used in this study[18].

Table 2. *Formula for the Financial Ratio.*

Financial Ratio	Formula
Current ratio	$\frac{\text{Current assets}}{\text{Current liabilities}}$
Debt to equity ratio	$\frac{\text{Total liabilities}}{\text{Total shareholders' equity}}$
Earnings per share (EPS)	$\frac{\text{Net profit}}{\text{Number of shares}}$
Return on equity (ROE)	$\frac{\text{Net profit}}{\text{Total shareholders' equity}} \times 100\%$

3.2. Data Envelopment Analysis

Data envelopment analysis (DEA)is a mathematical linear programming model which is utilized to evaluate the relative efficiency of the decision making units [5]. DEA model is used to describe how efficient thedecision makingunits are able to transform the inputs into outcomes or outputs. In DEA model, the efficiency of the unit is expressed as the ratio of the sum-weighted outputs to sum-weighted inputs. DEA model is able to handlemultiple inputs and outputs simultaneously. The unit that achieves an efficiency score of 100% will be treated as efficient unit, otherwise, the unit will be identified as inefficient unit. The DEA model is formulated as follows:

$$\text{Maximize } h_k = \frac{\sum_{r=1}^{s} t_r y_{rk}}{\sum_{i=1}^{m} w_i x_{ik}} \quad (1)$$

Subject to

$$\frac{\sum_{r=1}^{s} t_r y_{rj}}{\sum_{i=1}^{m} w_i x_{ij}} \le 1, \; j = 1,2,3,...,n \quad (2)$$

$$t_r \ge \varepsilon, \; r = 1,2,3,...,s \quad (3)$$

$$w_i \ge \varepsilon, \; i = 1,2,3,...,m \quad (4)$$

where

h_k is the relative efficiency of DMU_k

s is the number of outputs

t_r is the weights to be determined for output r

m is the number of inputs

w_i is the weights to be determined for input i

ε is the positive value

n is the number of entities

Equation (1) is an objective function which maximizes the efficiency for k-decision-making unit. Constraint (2) ensures that the efficiency is $0 < h_k \le 1$ for each DMU. The weights w_i and t_r show the importance of each input and output in maximizing the efficiency which is determined by the model.

The model above is a nonlinear with a linear and fractional objective function as well as the constraints. The model above can be transformed to linear programming form by maximizing the numerator and setting the denominator to 1 as shown in the model below[5, 19].

$$\text{Maximize } h_k = \sum_{r=1}^{s} t_r y_{rk} \quad (5)$$

Subject to

$$\sum_{i=1}^{m} w_i x_{ij} - \sum_{r=1}^{s} t_r y_{rj} \ge 0, \; j = 1,2,3,...,n \quad (6)$$

$$\sum_{r=1}^{m} w_i x_{ik} = 1 \quad (7)$$

$$t_r \ge \varepsilon, \; r = 1,2,3,...,s \quad (8)$$

$$w_i \ge \varepsilon, \; i = 1,2,3,...,m \quad (9)$$

4. Empirical Results

The empirical results for the efficiency and ranking of the healthcare companies are presented in Figure 1 and Table 3 respectively.

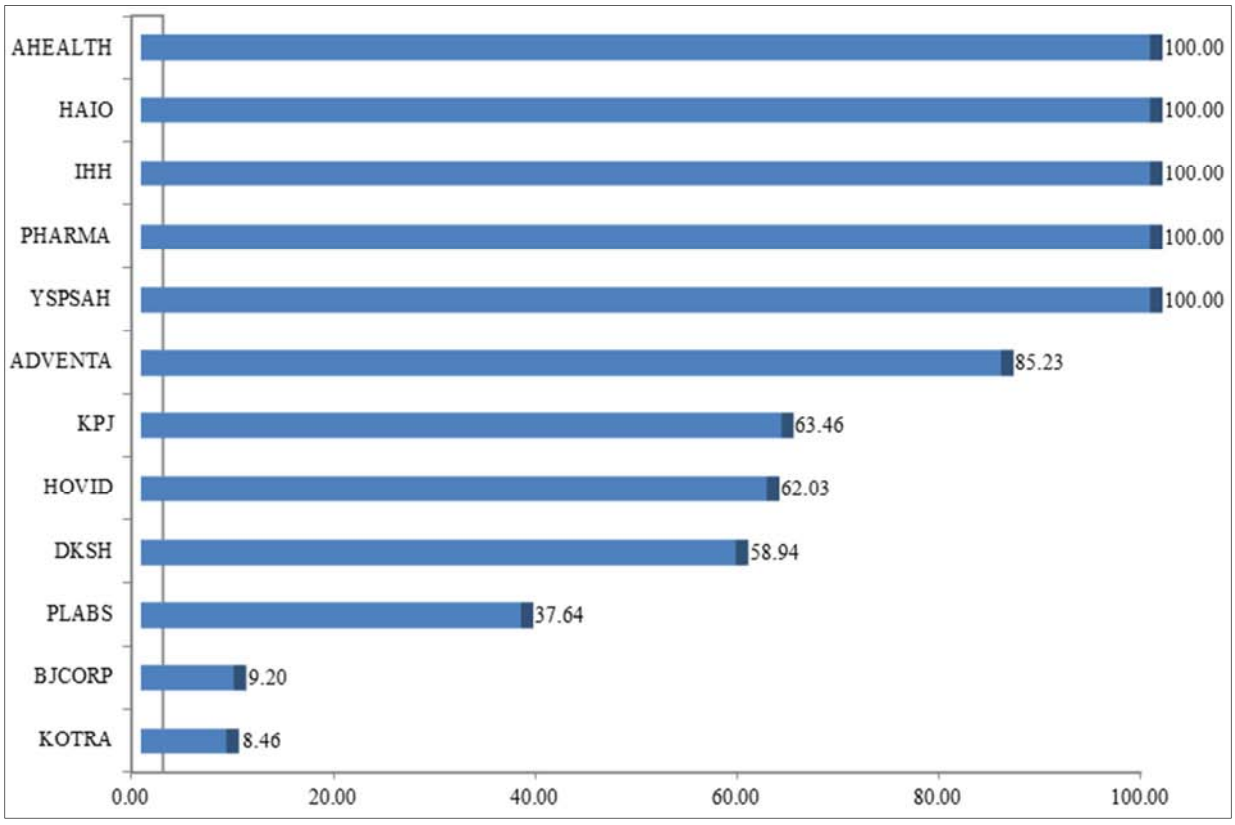

Figure 1. *Efficiency of Healthcare Companies.*

Table 3. *Ranking of Healthcare Companies.*

Company	Efficiency (%)	Rank
ADVENTA	85.23	6
AHEALTH	100.00	1
BJCORP	9.20	11
DKSH	58.94	9
HAIO	100.00	1
HOVID	62.03	8
IHH	100.00	1
KOTRA	8.46	12
KPJ	63.46	7
PHARMA	100.00	1
PLABS	37.64	10
YSPSAH	100.00	1

As shown in Figure 1 and Table 3, there are fivehealthcare companies which manage to achieve 100.00% efficiency in this study. These five companies are AHEALTH, HAIO, IHH, PHARMA and YSPSAH. This implies thatAHEALTH, HAIO, IHH, PHARMA and YSPSAH have fully utilized the inputs of current ratio and debt to equity ratio in maximizing the earnings per share (EPS) and return on equity(ROE) as outputs. On the other hand, for those healthcare companies which achieve the efficiency score below 100.00% are identified as inefficient healthcare companies. Therefore, ADVENTA, BJCORP, DKSH, HOVID, KOTRA, KPJ and PLABS are identified as inefficient companies in this study since their efficiencies are less than 100.00%. Based on Table 3, the efficiency score for ADVENTA, KPJ and HOVIDare 85.23%, 63.46% and 62.03%,respectively. As a result, ADVENTA, KPJ and HOVID obtain the sixth, seventh and eighth ranking respectively in this study. Moreover, BJCORP and KOTRA are not able to perform well as compared to other healthcare companies. This is because the efficiency score for BJCORP and KOTRA are 9.20% and 8.46% respectively, which are below 10.00%. In summary, AHEALTH, HAIO, IHH, PHARMA and YSPSAHare classified as efficient healthcare companies in Malaysia and therefore,these companies can serve as a benchmark to other inefficient companies for further improvement.

Table 4 presents the contribution of input/output weights in maximizing the efficiency by using DEA model.

Table 4. *Contribution of Input/Output Weights in Maximizing Efficiency.*

Company	Current ratio (Input 1)	Debt to equity ratio (Input 2)	EPS (Output 1)	ROE (Output 2)	Efficiency (%)
ADVENTA	0.48	99.52	0.00	100.00	85.23
AHEALTH	0.61	99.39	97.87	2.13	100.00
BJCORP	1.23	98.77	100.00	0.00	9.20
DKSH	1.23	98.77	100.00	0.00	58.94
HAIO	0.48	99.52	0.00	100.00	100.00
HOVID	18.63	81.37	0.00	100.00	62.03
IHH	0.00	100.00	100.00	0.00	100.00
KOTRA	0.00	100.00	0.00	100.00	8.46
KPJ	18.63	81.37	0.00	100.00	63.46
PHARMA	9.20	90.80	100.00	0.00	100.00
PLABS	0.00	100.00	0.00	100.00	37.64
YSPSAH	1.23	98.77	100.00	0.00	100.00

As presented in Table 4, the efficient companies with 100.00% efficiency consist of AHEALTH, HAIO, IHH, PHARMA and YSPSAH. In this study, AHEALTH, IHH, PHARMA and YSPSAH are the efficient companies which mostly utilize the output contribution from EPS in maximizing the efficiency. On the other hand, the maximum efficiency for HAIO is fully contributedby ROE as output. In conclusion, EPS is a significant factor in determining the maximum efficiency for most of the efficient companies. Moreover, the result shows that the input contributions to the efficient and inefficient companies are mainly contributed by debt to equity ratio rather than current ratio in maximizing the efficiency.

5. Conclusion

DEA is a mathematical linear programming model which measuresthe relative efficiency of the healthcare companies. In this study, five out of 12 healthcare companies are able to achieve 100% efficiency in Malaysia. AHEALTH, HAIO, IHH, PHARMA and YSPSAHare identified as efficient companiesand therefore,these companies can serve as a benchmark to other inefficient companies for further improvement. This study is significant because the DEA model helps to determine the efficient healthcare companies in Malaysia based on multiple inputs and outputs.

References

[1] S. Kumaraswamy, “Service quality in health care centres:An empirical study,” International Journal of Business and Social Science, Vol. 3, no. 16, pp. 141-150, 2012.

[2] K. Khanjankhani et al., “Evaluation and prioritization of service quality dimensions using Dematel and Topsis (A case study in Iran),” Bali Medical Journal, Vol. 5, no. 2, pp. 118-123, 2016.

[3] V. K. Omachonu, and N. G. Einspruch, “Innovation in Healthcare Delivery Systems: A conceptual framework,” The Innovation Journal: The Public Sector Innovation Journal, Vol. 15, pp. 1-20, 2010.

[4] E. H. Feroz, S. Kim, and R. L. Raab, "Financial statement analysis: A Data Envelopment Analysis approach," The Journal of the Operational Research Society, Vol. 54, pp. 48-58, 2003.

[5] A. Charnes, W. W. Cooper, and E. Rhodes, "Measuring the efficiency of decision making units," European Journal of Operational Research, Vol. 2, pp. 429-444, 1978.

[6] A. A. Kamil, and P. L. Ong, "Data Envelopment Analysis for stocks selection on Bursa Malaysia," Archives of Applied Science Research, Vol. 2, no. 5, pp. 11-35, 2010.

[7] C. Jehu-Appiah et al., "Ownership and technical efficiency of hospitals: Evidence from Ghana using Data Envelopment Analysis," Cost Effectiveness and Resource Allocation, Vol. 12, 2014.

[8] J. Akazili, M. Adjuik, C. Jehu-Appiah, and E. Zere, "Using Data Envelopment Analysis to measure the extent of technical efficiency of public health centres in Ghana," BMC International Health and Human Rights, Vol. 8, pp. 11-22, 2008.

[9] A. Rai, "Measurement of efficiency in the airline industry using Data Envelopment Analysis," Investment Management and Financial Innovation, Vol. 10, pp. 38-45, 2013.

[10] Y. L. Huang, I. F. Lee, and Y. H. Lee, "Modeling operational efficiency using Data Envelopment Analysis: Evidence from Atlantic City Hotels," Global Journal of Business Research, Vol. 6, no. 3, pp. 63-72, 2012.

[11] L. Asandului, M. Roman, and P. Fatulescu, "The efficiency of healthcare systems in Europe: A Data Envelopment Analysis approach," Procedia Economics and Finance, Vol. 10, pp. 261-268, 2014.

[12] A. R. Hernandez, and M. S. Sebastian, "Assessing the technical efficiency of health posts in rural Guatemala: A Data Envelopment Analysis," Global Health Action, Vol. 7, pp. 1-9, 2014.

[13] V. G. Valdmanis, M. D. Rosko, H. Leleu, and D. B. Mukamel, "Assessing overall, technical, and scale efficiency among homehealth care agencies," Health Care Management Science, pp. 1-11, 2016.

[14] Bursa Malaysia. (n.d.) *Company Announcements Bursa Malaysia Market*. [online] Available at: <http://www.bursamalaysia.com/market/listed-companies/company-announcements/#/?category=all> [Accessed 19 October 2016].

[15] J. E. Price, M. D. Haddock, and H. R. Brock, College accounting. 10th ed., New York, Macmillan/McGraw-Hill, 1993.

[16] P. Östring, Profit-Focused Aupplier Management. United State, American Management Association International, 2003.

[17] O. Akguc, Financial statement analysis. 13rd ed, Istanbul, Arayis Publication, 2010.

[18] C. P. Jones, Investments analysis and management. 12nd ed., Asia, John Wiley & Sons, 2013.

[19] M. M. Martic, M. S. Novakovic, and A. Baggia, "Data Envelopment Analysis – Basic models and their utilization," Organizacija,Vol. 42, no. 2, pp. 37-43, 2009.