Research Article

The Performance of Malaysian Universities Based on DEA Models

Norfarziah Adna[1, *], Nazhatul Sahima Mohd Yusoff[2], Nor Syafiqah Azwani Rosly[3], Nur Syafiqah Izzati Ahmad Marzuki[4], and Wan Nur Amira Balqis Wan Razali[5]

[1]   Universiti Teknologi MARA Kelantan; nfarziah65@uitm.edu.my ; (iD) 0000-0001-8022-0043

[2]   Universiti Teknologi MARA Kelantan; nazha237@uitm.edu.my

[3]   Universiti Teknologi MARA Kelantan; syafiqazwany@gmail.com

[4]   Universiti Teknologi MARA Kelantan; iekazati98@gmail.com

[5]   Universiti Teknologi MARA Kelantan; migha1998@gmail.com

*   Correspondence: nfarziah65@uitm.edu.my, 013-9308451.

Abstract: Universities play a vital role in a country's growth and have the potential to stay in the field of higher education by determining their performance. Thereby, management will not know whether university performance is profitable if it is not measured. Therefore, this project was carried out to determine the efficiency of public universities in Malaysia using Data Envelopment Analysis (DEA) models such as the Charnes, Cooper, and Rhodes model (CCR) and Slack-Based Measure model (SBM)Public higher education is under tremendous pressure worldwide to improve its performance and quality. This paper examines the efficiency scores of 20 public universities in Malaysia using the CCR and SBM. These 20 public universities state as Decision Making Unit (DMU) and DMU will be efficient if and only if the optimal value of efficiency is equal to 1; otherwise, it is inefficient. Three inputs and five outputs are determined to measure the performance of the university through the graduate student's marketability. The findings show that out of 20 public universities, 11 public universities are efficient with an efficiency score equal to 1. Meanwhile, the remaining nine public universities showed inefficient score results. Suggestions and improvements are identified to improve the efficiency of those universities in the future. To overcome inefficient universities, the use of the SBM model provides recommendations to consider in measuring efficiencies which are the number of postgraduate students enrolled, number of undergraduate students enrolled, and number of academic staff as the inputs and the number of postgraduates, number of undergraduates, number of graduates working, number of graduates who choose to further studies and number of graduates choose to develop skills as the outputs. All the criteria need to consider for the improvement for the universities to be more efficient.

Keywords: Charnes,Cooper & Rhodes; Efficiency; Slacks Based Measure Model.

1.   INTRODUCTION

The definition of high-level education may differ depending on the laws and culture of the country. Higher education is the third level of education after high school. There are a few similar features of higher education, regardless of which form of post-secondary school one attends. Thus, higher education is any of the different types of education provided in postsecondary institutions of learning that leads to the granting of a specified degree, diploma, or certificate of higher studies at the end of a course of study (Chang, X.; Wang, X, 2020). Higher-educational institutions include not only

universities and colleges, but also professional schools that prepare students for careers in science mathematics, law, theology, medicine, business, music, and the arts. The completion of secondary education is the most common admission criteria for most higher-educational institutions, and the average entrance age is around 18 years old (Collegiate, 2020). The Ministry of Higher Education is in charge of regulating the operation of Malaysia's higher education institutions (HEIs). The performance of Malaysian Public Universities can be measured by looking at how public universities effectively manage all resources to generate the required output. The performance of HEIs determines their ability to sustain themselves in the higher sector (Volchik & Maslyukova 2017). In this paper, the relative performance of public universities in Malaysia is examined during the student transition process to determine which university will generate the highest quality students based on the needs within the job market. Therefore, the Data Envelopment Analysis (DEA) models are used to calculate each DMU's relative output. Here, CCR and SBM models will be applied to the data to measure the efficiency and performance of the DMUs of Malaysian public universities.

2.   METHOD & MATERIAL

Data Envelopment Analysis (DEA) was introduced by Charnes, Cooper, and Rhodes (1978). It is a common non-parametric model that most often uses linear programming techniques for measuring the relative efficiency of Decision-Making Units (DMUs) in the presence of multiple inputs and multiple outputs to establish an efficiency frontier. It measures the overall performance evaluation of a set of homogeneous DMUs, which provides an efficiency score between 0 and 1 for each DMU and indicates the possible growth or decrease of each selected factor (Ismail. I. *et al*, 2020). The most outstanding function of this method is that each DMU can choose the most favourable weights (multipliers) for the inputs and outputs when calculating efficiency. Due to this feature, DEA is a vital decision-making tool that has been widely used in many real-world applications such as health care, education, banking, sport, and so on. The basic purpose of DEA is to compare the efficiency of several DMUs in changing inputs into outputs. DEA also has the advantage of not requiring any assumptions regarding the functional form of the model that supports the relationships between the input and output variables (Gosken et al,2015). In this project, the DEA models are used to measure the efficiency and performance of the DMUs of Malaysian public universities. This study suggests several research objectives be attained such as to determine the efficiency scores of public universities in Malaysia using Charnes, Cooper, and Rhodes (CCR) model and Slack-Based Measure (SBM) model.

2.1 Charnes, Cooper, and Rhodes (CCR) and Slack-Based Measure (SBM) model

There are two models used to measure the efficiency of public universities in Malaysia, which are the CCR model and the SBM model.

Model 1: Charnes, Cooper and Rhodes (CCR) model

The CCR model for DMU_0 set up, respectively, as:

$$\text{Minimum } \tau = t$$

$$\text{subject to } \sum_{j=i}^{n} x_{ij}u_j + t_i^{-} \le tx_{i0}$$

$$\sum_{j=1}^{n} y_{rj}u_j - t_r^{+} \le y_{r0}$$

$$u_j \ge 0, t_r^{+} \ge 0, t_i^{-} \ge 0$$

where n is the number of DMU, y_{r0} is the output of DMU_0, y_{rj} is the output of DMU_j, x_{i0} is the input of DMU_0 and x_{rj} is the input of DMU_j.

Model 2: Slack-Based Measure (SBM) model

The Slack-Based Model that used to evaluate the efficiency of DMU_0 is defined as follows:

$$\text{Minimum} \quad \tau = t - \frac{1}{m}\sum_{i=1}^{m}\frac{S_i}{x_{i0}}$$

$$\text{subject to} \quad 1 = t + \frac{1}{s}\sum_{r=1}^{s}\frac{S_r^{+}}{y_{r0}}$$

$$tx_{i0} = \sum_{j=1}^{n} x_{ij}L_j + S_i^{-}$$

$$ty_{r0} = \sum_{j=1}^{n} y_{rj}L_j - S_r^{+}$$

$$L \geq 0, \ S^{-} \geq 0, \ S^{+} \geq 0, \ t \geq 0 \text{ with } S^{-}=ts^{-}, \ S^{+}=ts^{+}, \text{ and } tL = tl$$

where S_i^{-} the slack in the ith input and S_r^{+} is the slack in the rth output. Efficiency is measured by additional variables s^+ and s^-. The researcher demonstrated that the SBM efficiency rate is always less than or equal to the efficiency rate of the CCR model (Vincova, 2005). This means that a unit rated as SBM efficient is CCR efficient at the same time. In this model, n is the number of DMU, $r = 1,…,s$ is the total number of the output, and $i = 1,…,m$ is the total number of the input. Hence, x_{i0} and y_{r0} are the input and the output for a particular DMU respectively.

3. FINDINGS

In this study, the secondary data used from the article "Relative Efficiency of Public Universities in Malaysia" (Irliana *et al.*,2014). The data consists of the relative efficiency of 20 public universities of Malaysia in the students' transition process in 2011. There are three inputs and five outputs selected to determine the effectiveness of the public universities based on the demand of the graduated students. The three inputs and five outputs are considered in measuring efficiencies: number of postgraduate students enrolled, number of undergraduate students enrolled and number of academic staff as the inputs and number of postgraduates, number of undergraduates, and number of graduates working, number of graduates who choose to further studies and number of graduates choose to develop skills as the outputs. The input and output data of the universities can be referred to in Table 1.

Table 1: List of DMU with input and output data (Irliana *et al.* 2014)

DMUs	Input			Output				
	Postgraduate students enrolled	Undergraduate students enrolled	Academic Staff	Postgraduates	Undergraduates	Graduates working	Graduates who choose to further studies	Graduates choose to develop skills
UM	2471	3502	2076	1799	4127	3818	255	105
USM	2048	5635	2031	1121	4471	3236	387	31

UKM	2872	3168	2158	1278	5086	4185	272	73
UPM	3208	5030	1524	1736	4201	4313	597	52
UTM	2975	5176	2007	791	3821	3272	894	58
UUM	1651	5645	1215	1445	6358	5361	154	118
UIAM	902	4347	2135	591	2868	2149	251	306
UNIMAS	213	4154	709	122	1229	801	62	45
UMS	261	4311	896	62	3570	2284	118	73
UPSI	545	10050	609	334	3077	1141	20	7
UITM	3218	28228	8482	1589	19133	14833	12725	465
UNISZA	39	1331	406	1	440	281	310	7
UMT	88	2301	383	79	1617	776	194	24
USIM	117	2505	478	44	1120	682	45	43
UTHM	739	4010	676	165	1832	1174	277	32
UTEM	270	2552	656	100	1082	701	259	28
UMP	80	2102	583	29	716	650	154	21
UNIMAP	76	2125	630	43	952	501	172	28
UMK	96	1104	215	3	266	137	6	6
UPNM	15	580	213	0	406	177	15	24

4.   DISCUSSION

Measuring efficiency is a means rather than an end and its goal is to find the direction for each DMU to make improvements. The efficiency score of 20 DMUs in this study were measured using the CCR and SBM models. Table 2 shows the efficiency score obtained using CCR and SBM models.

Table 2: CCR and SBM score for 20 public universities in Malaysia

DMUs	Code	CCR Score	SBM Score
1	UM	1.0000	1.0000
2	USM	0.7221	0.3677
3	UKM	1.0000	1.0000
4	UPM	1.0000	1.0000
5	UTM	0.7319	0.5025
6	UUM	1.0000	1.0000
7	UIAM	1.0000	1.0000
8	UNIMAS	0.7198	0.2622
9	UMS	1.0000	1.0000
10	UPSI	1.0000	1.0000
11	UITM	1.0000	1.0000
12	UNISZA	1.0000	1.0000
13	UMT	1.0000	1.0000
14	USIM	0.8697	0.4206

15	UTHM	0.6533	0.4288
16	UTEM	0.5489	0.4968
17	UMP	0.8908	0.5534
18	UNIMAP	0.8414	0.6828
19	UMK	0.3145	0.0565
20	UPNM	1.0000	1.0000

According to Table 2, eleven DMUs are efficient with the efficiency scores of the DMUs being equal to 1 and it has no input excess and no output shortfall. Based on Tone (2011), a DMU is efficient for the SBM model if the CCR score is efficient. The list of efficient universities is UM, UKM, UPM, UUM, UIAM, UMS, UPSI, UITM, UNISZA, UMT, and UPNM with the efficiency score equal to 1. The remaining nine inefficient universities with a score efficiency below 1 are USM, UTM, UNIMAS, USIM, UTHM, UTEM, UMP, UNIMAP, and UMK. Both models indicate the same result whereby eleven universities are efficient while another nine universities are inefficient. However, the SBM model provides more detailed and accurate results for inefficiency scores from the perspective of input excess and output shortfall. The result of score efficiency with input excess and output shortfall in percentages of the DMUs are shown in Table 3.

Table 3: Result of score efficiency with input excess and output shortfall in public universities

No	DMUs	ρ	s_1^-	s_2^-	s_3^-	s_1^+	s_2^+	s_3^+	s_4^+	s_5^+
1	UM	1.0000	0	0	0	0	0	0	0	0
2	USM	0.3678	28.85%	0	0	0	11.98%	25.68%	0	691.07%
3	UKM	1.0000	0	0	0	0	0	0	0	0
4	UPM	1.0000	0	0	0	0	0	0	0	0
5	UTM	0.5025	63.88%	0	14.16%	0	12.45%	5.19%	0	218.53%
6	UUM	1.0000	0	0	0	0	0	0	0	0
7	UIAM	1.0000	0	0	0	0	0	0	0	0
8	UNIMAS	0.2622	0	30.82%	0.12%	0	61.44%	52.94%	200.70%	0
9	UMS	1.0000	0	0	0	0	0	0	0	0
10	UPSI	1.0000	0	0	0	0	0	0	0	0
11	UiTM	1.0000	0	0	0	0	0	0	0	0
12	UNISZA	1.0000	0	0	0	0	0	0	0	0
13	UMT	1.0000	0	0	0	0	0	0	0	0
14	USIM	0.4206	0	37.25%	0	20.31%	0	0	100.94%	0
15	UTHM	0.4288	51.62%	40.51%	0	39.40%	0	24.10%	214.97%	29.45%
16	UTEM	0.4968	24.99%	30.40%	18.63%	0	11.28%	33.16%	209.20%	4.51%
17	UMP	0.5334	0	5.76%	42.16%	138.76%	90.04%	4.40%	21.77%	0
18	UNIMAP	0.6829	0	8.40%	39.75%	39.50%	43.45%	31.73%	0	0

| 19 | UMK | 0.0564 | 53.40% | 64.46% | 45.15% | 136.37% | 0 | 50.52% | 0 | 7.75% |
| 20 | UPNM | 1.0000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

5.   CONCLUSION

DEA is used to measure efficiency and comparable DMUs relative to one another. This study proposes a method to compare the performance of public universities in Malaysia by using CCR and SBM models. The finding of this study will help to analyze the performance and productivity change in the higher education sectors such as public universities. This is because it will give valuable information to produce better-educated, skilled workers and achieve the nation's aspiration to become a developed country. Another significance of this finding is it will help the management of public universities which can be exposed to the measurability performance of universities that would provide them with the better understanding to maintain the efficiency of the universities which will maximize its performance.

References

Chang, X.; Wang, X. Research Performance Evaluation of University Based on Super DEA Model. IEEE 9th Joint International Information Technology and Artificial Intelligence Conference (ITAIC) 2020, 19, 1252–1255.

Collegiate. The main advantages of going to University Available online: https://www.collegiate ac.es/en/student-news/advantages-go-university/(accessed on 2020).

Göksen Y., Doğˇan O. & Özkarabacak B. 2015. A Data Envelopment Analysis application for measuring efficiency of university departments. *Procedia Economics and Finance* **19**(15): 226–237.

Ismail, I.; Ramalingam, S.; Azahan, A. H.; Khezrimotlagh, D. Relative Efficiency of Public Universities in Malaysia. Economics, Business and Management 2014, 1, 606–612.

Irliana I., Econ S.J., Manag B., Ismail I., Ramalingam S., Azahan A.H. & Khezrimotlagh D. 2014. Relative efficiency of public universities in Malaysia. *Scholars Academic and Scientific Publishers* **1**(11): 606–612.

Tone, Kaoru. (2011). Slacks-Based Measure of Efficiency. 10.1007/978-1-4419-6151-8_8.

Vincova K (2005) Using DEA models to measure efficiency. BIATEC, Volume XIII. http://www.nbs.sk/_img/Documents/BIATEC/BIA08_05/24_28. Accessed: March 2017.

Visbal-Cadavid D., Martínez-Gómez M. & Guijarro F. 2017. Assessing the efficiency of public universities through DEA. A case study. *Sustainability* **9**(8): 1416.

Volchik V. & Maslyukova E. 2017. Performance and sustainability of higher education: key indicators versus academic values. *Journal of Security and Sustainability Issues* **6**(3): 501-512.