Research Article

Measuring the Performance of Public Universities Malaysia Using CCR Model and Ranking with Super Efficiency Model

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Abstract: The efficiency and productivity of a country's higher education system significantly influence its ability to develop and flourish. Furthermore, efficiency becomes a crucial performance metric for universities overall, assisting decision-makers in formulating policies that promote the intended outcomes and prudently allocating resources. There is a lot of pressure on public higher education around the world to perform better and be of higher quality. This study examines the efficiency scores of 20 public universities in Malaysia using the input-oriented CCR model and output-oriented CCR model and also the Super Efficiency model. Three inputs and five outputs are determined to measure the performance of the university. The number of postgraduate students enrolled, the number of undergraduate students enrolled, and the number of academic staff are the inputs, while the number of graduates, the number of graduates working, the number of graduates who choose to further studies, the number of graduates who choose to develop skills, and the number of graduates waiting for work placement are the outputs. The findings show that out of 20 public universities, 13 public universities are efficient with an efficiency score equal to 1 using the input-oriented CCR model and output-oriented CCR model. Meanwhile, the remaining seven public universities showed inefficient score results. UNIMAP got 4.103862 for the Super Efficiency score, which was ranked first out of thirteen efficient public universities in 2023, making it the most efficient public university. By ranking public university, interested parties, such as the higher education sector or university administration, can take steps to enhance and maximize university performance.

Keywords: Charnes, Cooper & Rhodes; Efficiency, Super Efficiency.

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1. INTRODUCTION

In 2011, there were 20 public universities, 50 private universities, 6 branch campuses of foreign universities, 403 active private colleges, 30 polytechnics and 73 public community colleges in Malaysia, a nation of more than 28.3 million people with a diversified population (StudyMalaysia.com, 2022). Many tertiary qualifications are available at reasonable costs from these Higher Education Institutions (HEIs). Research university status and increased funds for research and development, as well as commercialization, have been granted to five of Malaysia's twenty public universities. Either comprehensive universities or focus universities apply to the remaining fifteen public universities. The Minister of Higher Education declared in the 2012 New Year's speech that five public institutions now have autonomy over their finances, human resources, academic program, and admissions. University

Malaya, University Kebangsaan Malaysia, University Sains Malaysia, University Putra Malaysia, and University Teknologi Malaysia are the names of these universities. This action is meant to promote excellence in higher education institutions in the area. The Malaysian Qualifications Agency (MQA) is responsible for implementing the Malaysian Qualifications Framework and guaranteeing the quality of higher education. In addition to overseeing public and private higher education institutions, MQA is also in charge of quality assurance, course accreditation, and other associated duties.

According to Dzulkarnain et al. (2024), starting with a thorough performance evaluation of their efficiency operations is the first step in improving public universities' performance. Not only that, efficiency turns into a critical performance indicator for universities as a whole, helping policymakers create policies that support desired results and allocate resources wisely. The efficiency of higher education has been frequently assessed using DEA models (Ramzi & Ayadi, 2016). As stated by Panwar et al. (2022), Data Envelopment Analysis (DEA), which is a methodology proposed by Charnes et al. in 1978, approximately twenty years later, is used to determine the relative efficiency of units based on an input and numerous outputs. Efficiency was defined by him as the weighted sum of the outputs divided by the weighted sum of the inputs. The two industries where DEA has been used the most frequently, from an application point of view, are banking and education. This study uses the Charnes, Cooper, and Rhodes (CCR) models, which are input-oriented CCR model (CCR-I) and output-oriented CCR model (CCR-O), and also super efficiency (SE) model to evaluate public universities' performance. The CCR model is used in this study to assess public universities' efficiency, and the SE model is used to identify and suggest which public institutions are the most efficient. Many application areas have made substantial use of the SE model, including ranking efficient Decision-Making Units (DMUs), finding extreme efficient DMUs, and measuring efficiency regions (Panwar et al., 2022). The data were taken from Ministry of Higher Education to examine the relative efficiency of 20 public universities in Malaysia and stated as Decision Making Unit (DMU). The data of Public Universities in Malaysia are shown in Table 1.

Table 1: Data of public universities in Malaysia for the year 2023

Public Universities Malaysia	DMU	Code
Universiti Malaya	A	UM
Universiti Sains Malaysia	B	USM
Universiti Kebangsaan Malaysia	C	UKM
Universiti Putra Malaysia	D	UPM
Universiti Teknologi Malaysia	E	UTM
Universiti Utara Malaysia	F	UUM
Universiti Islam Antarabangsa Malaysia	G	UIAM
Universiti Malaysia Sarawak	H	UNIMAS
Universiti Malaysia Sabah	I	UMS
Universiti Pendidikan Sultan Idris	J	UPSI
Universiti Teknologi Mara	K	UiTM
Universiti Sultan Zainal Abidin	L	UniSZA
Universiti Malaysia Terengganu	M	UMT
Universiti Sains Islam Malaysia	N	USIM
Universiti Tun Hussein Onn Malaysia	O	UTHM
Universiti Teknikal Malaysia Melaka	P	UTeM
Universiti Malaysia Pahang Al-Sultan Abdullah	Q	UMPSA
Universiti Malaysia Perlis	R	UNIMAP
Universiti Malaysia Kelantan	S	UMK
Universiti Pertahanan Nasional Malaysia	T	UPNM

2. METHODOLOGY

DEA is a non-parametric method that Charnes et al. (1978) proposed that uses mathematical programming. It is principal goal is to evaluate the comparative effectiveness of a homogeneous peer set of decision-making units (DMUs) that use various inputs to generate different outputs (Taleb et al., 2023). The methodology uses to evaluate Malaysia public universities' performance in 2023 use the input-oriented CCR (CCR-I) model and output-oriented CCR (CCR-O) also Super Efficiency (SE) models. According to Durana et al. (2020), a production unit that is inefficient can use the input-oriented model (CCR-I), which suggests lowering input while keeping output at the same level, or the output-oriented model (CCR-O), which suggests raising output while keeping input at the same level. Meanwhile, in order to differentiate between efficient DMUs, Anderson and Peterson (1993) proposed the Super Efficiency measure. It provides the ability to rank efficient DMUs that are defined by similar relative efficiency scores that are equal to one under the initial DEA model's estimation. There are three models used to measure the efficiency of public universities in Malaysia, which are the input-oriented CCR, output-oriented CCR and super efficiency model.

Model 1: Input-Oriented CCR (CCR-I) model

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

Minimum $\tau = t$

Subject to

$$\sum_{j=i}^{n} x_{ij}u_j + {t_i}^- \leq t x_{i0}$$

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

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

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_{ij} is the input of DMU_j.

Model 2: Output-Oriented CCR (CCR-O) model

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

Minimum $\tau = t$

Subject to

$$\sum_{j=i}^{n} x_{ij}u_j - {t_i}^- \leq x_{i0}$$

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

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

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

Model 3: Super Efficiency model

The Super Efficiency (SE) model that used to rank various of DMU_0 is defined as follows:

Maximum $\sum_{r=1}^{s} y_{r0}u_r$

Subject to

$$\sum_{i=1}^{m} x_{i0}v_i = 1$$

$$\sum_{r=1}^{s} y_{rj}u_r - \sum_{i=1}^{m} x_{ij}v_i \leq 0$$

$$v_i \geq 0, u_r \geq 0$$

where $v_i(i = 1, \dots, m)$ and $u_r(r = 1, \dots, s)$ be the weights of the ith input and rth output, respectively. In this model, $i = 1, \dots, m$ is the total number of inputs, $r = 1, \dots, s$ is the total number of the output. Hence, x_{i0} and y_{r0} are the input and the output for a particular DMU respectively. Arabmaldar et al. (2017) stated that the Super Efficiency (SE) model subtracts this DMU from the group of DMUs in order to calculate the SE score of the DMU that is being evaluated. Following this removal, the efficient frontier takes on a new form, and the new score calculates the separation between the original DMU and the new frontier.

3. FINDINGS

Next, the data from the Decision-Making Unit (DMU) is secondary data that is referenced in the annual report and website. Data Envelopment Analysis (DEA) is used to compare input-oriented CCR model and output-oriented CCR model. The efficient of the public universities was evaluated using three inputs and five output. The data from twenty public universities are included in Table 2 below to determine which public universities will perform well and how efficient they are. Then, these data were analysed using LINGO 20.0 that generated the efficiency scores.

Table 2: The DMUs of Data Acquisition

	Input			Output				
DMUs	**Post-graduate students enrolled**	**Under-graduate students enrolled**	**Academic staff**	**Number of graduates**	**Graduates working**	**Graduates who choose to further study**	**Graduates choose to develop skills**	**Graduates waiting for work placement**
A	13887	22292	2194	8373	5257	570	205	248
B	12871	22201	1983	8153	4632	307	375	758
C	13155	19949	1990	8957	5416	296	86	371
D	10365	17171	1795	6534	3807	342	640	410
E	8105	21092	1654	6497	4485	558	690	211
F	5135	25317	1186	6629	4026	55	156	765
G	3501	17922	2064	4726	2578	281	106	300
H	2322	13432	867	3841	2758	297	182	218
I	2651	15568	1101	4121	3273	194	199	402
J	5601	19097	844	7497	5771	586	150	481
K	10242	168479	8909	54109	28563	13952	268	399
L	1803	12953	773	3555	1978	1064	129	119
M	1377	9543	647	2387	1824	240	31	46
N	1193	11622	832	3122	2448	150	52	173
O	2574	16164	1129	4836	3333	820	76	160
P	1159	12972	868	3369	2501	513	120	52
Q	1413	11483	758	4886	3460	713	141	130

R	1072	11092	1121	3554	2287	583	439	99
S	751	13598	524	2159	2309	103	49	186
T	380	3400	392	1661	1307	99	10	22

4. DISCUSSION

The efficiency score of 20 DMUs in this study were measured using the input-oriented CCR model, output-oriented CCR model and SE model. Table 3 and Table 4 shows the efficiency scores obtained using input-oriented CCR model, output-oriented CCR model and SE model.

4.1 The efficiency scores of Input-Oriented CCR and Output Oriented CCR Models

The CCR-I model produced the efficiency scores for 20 public universities in Malaysia. Table 3 below presents the implementation's efficiency score using CCR-I and CCR-O models.

Table 3: CCR-I and CCR-O Score for 20 public universities in Malaysia

DMUs	Code	CCR-I Score	CCR-O Score
A	UM	0.839169	1.000000
B	USM	1.000000	1.000000
C	UKM	1.000000	1.000000
D	UPM	1.000000	1.000000
E	UTM	1.000000	0.984742
F	UUM	1.000000	1.000000
G	UIAM	0.750110	1.000000
H	UNIMAS	0.854842	0.817725
I	UMS	1.000000	0.849121
J	UPSI	1.000000	0.663447
K	UiTM	1.000000	1.000000
L	UniSZA	1.000000	1.000000
M	UMT	0.618031	1.000000
N	USIM	0.974581	0.954555
O	UTHM	0.794814	0.855927
P	UTeM	0.813387	1.000000
Q	UMPSA	1.000000	0.594090
R	UNIMAP	1.000000	1.000000
S	UMK	1.000000	1.000000
T	UPNM	1.000000	1.000000

Accordingly, a DMU is considered efficient if its efficiency score is 1, and inefficient if it is less than that, following evaluation and implementation using Lingo software. The list of efficient universities for CCR-I are USM, UKM, UPM, UTM, UUM, UMS, UPSI, UiTM, UniSZA, UMPSA, UNIMAP, UMK and UPNM. The remaining seven inefficient universities for CCR-I with a score efficiency below 1 are UM, UIAM, UNIMAS, UMT, USIM, UTHM and UTeM. For CCR-O, the list of efficient universities is UM, USM, UKM, UPM, UUM, UIAM, UiTM, UniSZA, UMT, UTeM, UNIMAP, UMK and UPNM. Meanwhile, the list of inefficient universities is UTM, UNIMAS, UMS, UPSI, USIM, UTHM and UMPSA. Both models indicate the same result whereby thirteen universities are efficient while another seven universities are inefficient but with different DMU. According to Fancello et al. (2020), both input and output approaches can benefit from the strong hierarchy that the CCR model can offer. It appears that the CCR model offers a more unbiased and comprehensive evaluation of the DMU's performance.

4.2 The result of Super Efficiency model and ranking

In order to rank the public universities, this study uses the CCR-I results to compute super efficiency. Because CCR-I minimizes inputs while retaining the same level of outputs, it was used to calculate super efficiency. It works better in settings with fewer resources, like the education sector, where funding for inputs is strictly regulated. The results of the Super Efficiency (SE) model and the ranking of Malaysian public universities are shown in Table 4 below.

Table 4: The result of SE model and rank of public universities in Malaysia

DMUs	Code	SE Score	Rank
R	UNIMAP	4.103862	1
K	UiTM	2.346671	2
S	UMK	1.853650	3
J	UPSI	1.621997	4
F	UUM	1.380591	5
T	UPNM	1.375702	6
Q	UMPSA	1.280364	7
D	UPM	1.234119	8
B	USM	1.225754	9
L	UniSZA	1.187288	10
E	UTM	1.114992	11
I	UMS	1.098185	12
C	UKM	1.028754	13

In the SE CCR model, it is possible to precisely rank the efficient facilities, just as it was able to rank the inefficient facilities in the CCR-I model. UNIMAP received the top ranking as the most efficient public university in 2023, as indicated in Table 4. UiTM and UMK came in second and third place, respectively, as efficient public universities in 2023. Ranking public universities and measuring their super efficiency are important especially for the higher education sector because they can aid in decision-making by providing information and analysing university performance, which helps them better understand how to assist universities in improving and optimizing their performance.

5. CONCLUSION

DEA is used in this study to compare the efficiency and performance of different DMUs. This study proposes a method to compare the performance of public universities in Malaysia by using the input-oriented CCR model, output-oriented CCR model and Super Efficiency model. Through the analysis of university performance and the provision of information, the study's findings will help the higher education sectors better understand how to assist universities in improving and maximizing their performance. This study uses CCR-I model, as well as the CCR-O model of DEA analysis, to evaluate efficiency of public universities. Other than that, this study also uses SE model to determine the most efficient of public universities in 2023. The removal of the restriction regarding to the highest value of the efficiency evaluation of the DMU under study allowed for a more thorough and comprehensive description of the efficient universities. Future studies should investigate different fields such as hotels, sports, agriculture, fishery, transportation, tourism, health care, automobile and others to evaluate the performance.

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