

HOW EFFICIENT ARE MALAYSIAN PUBLIC UNIVERSITIES? A COMPARATIVE ANALYSIS USING DATA ENVELOPMENT ANALYSIS

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ABSTRACT

This paper aims to examine the efficiency of Malaysian public universities in comparison with the private and foreign universities using Data Envelopment Analysis (DEA). The study involves 22 universities (17 public, 1 private and 4 foreign) and based on data between year 2008 and 2011. Results reveal that the most efficient Malaysian public universities are: University Malaya (among research universities); Universiti Teknologi Mara (among comprehensive universities) and Universiti Utara Malaysia (among focused universities). When these three most efficient Malaysian public universities are compared with the private university in Malaysia and another 4 foreign universities, they are found to be inefficient in income generation and in managing inputs which include the government operating grant. The plausible explanation could be associated with a long history of over-dependence on government grants that may have resulted in the public universities becoming too complacent. The study calls for mechanisms to re-strategise and to get these public universities to be more financially independent.

Keywords: efficiency analysis, Data Envelopment Analysis (DEA), Malaysian public universities

INTRODUCTION

Human capital has been regarded as one of the main drivers of a country's growth towards having a knowledge (K) - economy. In this context, the higher education sector plays an important role in training and in cultivating graduates of the highest quality as part of the nation building agenda. Malaysia higher education sector has experienced remarkable growth since mid-1990s. However, the cost of higher education in Malaysia has also increased tremendously over the years. Malaysia has been ranked the fifth most expensive place to get a university education relative to its household income. It is reported that on the average, more than half of the salaries of Malaysian working parents were spent on their children's higher education (Chan, 2015).

The Malaysian government spending on higher education has been ranked the second highest among the world in terms of percentage of GDP (Ranking Reveals World's, 2013). A sharp increase of government spending in higher education is reflected from only RM1,727 million in the 5th Malaysia Plan to RM16,069 million in the 9th Malaysia Plan (Lee, 2014). In the 2015 Universitas 21 Ranking, in terms of resources allocated to higher education (measured by expenditure of tertiary education), the ranking of Malaysia is at an impressive position of top 12th (Williams, Leahy, Rassenfossé & Jensen, 2015).

Thus, given the huge amount of resources that Malaysia have been invested in its higher education sector, how did the Malaysian public universities fare in output performance? In the 2015 Universitas 21 Ranking, Malaysia was ranked 44th in the output ranking (measured by research output and impact, student employability, stock of research, and other output related indicators) which is far below the ranking of resource allocated (top 12th). Similarly, in The Times Higher Education World University Rankings 2015–2016, the highest ranking obtained by the Malaysian public universities (Universiti Teknologi Malaysia) only managed to fall in the 401st to 500th group.

The output performance of Malaysian public universities appeared to be incommensurate with the high amount of Malaysian public spending in higher education. The public universities might be inefficient in utilising the inputs (including the government funds), i.e., occurring of input slacks.¹ The large amount of higher education spending from public funds and the relatively low performance warrant a careful examination on the efficiency of the public universities in Malaysia. To our knowledge, there are only a few efficiency studies of public spending on Malaysian higher education institutions; none of them compared the efficiency and input slack of Malaysian public universities to the private and foreign universities.

Thus, this study aims to address the following research questions: How efficient is the public universities' spending (inputs) in producing the outputs? Are there any slacks in the spending (inputs)? How efficient are our public universities' spending as compared to the private and foreign universities? What are the efficiency gaps between universities? Using Data Envelopment Analysis (DEA), this study aims to analyse the efficiency and input slacks of Malaysian public universities as compared to private and foreign universities.

LITERATURE REVIEW

Measuring the efficiency of public universities is not an easy task. The common challenges faced by researchers are due to the characteristics of a public university which is a non-profit organisation, having simultaneous production of multiple outputs, using a variety of inputs, and lacking of price information (Johnes, 2006, 2008; Salleh, 2012). This diversification of inputs and outputs has led to no commonly accepted measurements of efficiency. In Malaysia, difficulties in collecting input and output information are the added barriers in measuring the efficiency of public universities' spending. Thus, it is not surprising, to our knowledge, there are limited studies in the efficiency of public spending on Malaysian higher education institutions. This situation has been pointed out by Worthington (2001) more than a decade ago that there are very few studies on higher education efficiency in developing countries, including Malaysia. So far efficiency studies on public universities in Malaysia include: Arjomandi, Salleh and Mohammadzadeh (2015), Irliana Ismail, Ramalingam, Amir Husaini Azahan and Khezrimotlagh (2014), Mualwana Abdul Talib (2005), and Salleh (2012).

Arjomandi, Salleh and Mohammadzadeh (2015) measure the efficiency changes among the Malaysia public universities before and after the implementation of National Higher Education Strategic Plan (NHESP) 2007. The efficiency of Malaysian public universities in producing outputs (number of refereed articles, undergraduate and postgraduate degree awarded) using the inputs (undergraduate enrolment, postgraduate enrolment, academic staff, and government research funding) are found to have increased substantially after the implementation of NHESP 2007. Efficiency scores among the universities are found to be similar ranging from 0.9292 to 1.0000 (Arjomandi, Salleh & Mohammadzadeh, 2015).

On the other hand, an earlier study by Mualwana Abdul Talib (2005) found that public universities are inefficient and input slacks exist which indicate potential cost reduction for these universities. This highlights the lack of efficiency of Malaysian public universities during the early 2000s. Using a sample of 17 public universities

in Malaysia, Salleh (2012) conducted an analysis on how efficiently the public universities use the inputs of undergraduate enrolment, postgraduate enrolments, academic staffs and government research funding in producing the output of graduates (undergraduates and postgraduates). It is found that the Malaysian public universities are relatively efficient with mean efficiency scores close to one and it is concluded that this high efficiency may be due to the global competitive pressures. Irliana Ismail et al. (2014) ranked all the 20 public universities in Malaysia in terms of their efficiency in producing quality students that meet the job market demand. Their results revealed that there are 12 public universities (out of the 20) which have almost similar efficiency scores.

Since efficiency analysis is a relative measurement, similarity in efficiency scores found in Salleh (2012), Irliana Ismail et al. (2014), and Arjomandi, Salleh & Mohammadzadeh (2015) might be due to homogeneity among the public universities (which are clustered by research, comprehensive and focused university). DEA is a relative measurement method using mathematical linear programming techniques, thus, a more meaningful analysis is to compare the efficiency of public universities to the private or foreign universities. This comparison enables us to gauge the efficiency gaps between Malaysian public universities and the private or foreign universities. The efficiency analysis that restricted only to the Malaysian public universities is likely to produce high efficiency scores for all, as what we have been seen in the previous studies. As a consequence, the Malaysian public universities appear to operate at high level of efficiency.

The efficiency of various academic departments within a public university has also been evaluated by previous studies. For example, Ng and Rohanin Ahmad (2012) analyses the efficiency of 28 academic departments of Universiti Teknologi Malaysia (UTM) in teaching and research (undergraduate degree awarded, postgraduate degree awarded and number of research grants) by using inputs of non-doctoral academic staff, doctoral academic staff, and non-academic staff. The input slacks and the scale of production of various departments are the focus of analysis. It is found that only a small number of departments are producing at a decreasing return of scales and 10 departments are found to be efficient. Similar to the study by Salleh (2012), Ng and Rohanin Ahmad (2012) study may suffer from the homogeneity bias due to the absence of a benchmarking Decision Making Unit (DMU). The performance of Malaysia universities are also evaluated using the indicators that related to productivity (Prathap & Ratnavelu, 2015). University Malaya (UM) and Universiti Sains Malaysia (USM) are identified as the leading universities in research productivity.

In Malaysia, other than the higher education institutions, analysis of efficiency (using DEA) has also been applied to other fields such as public-listed companies, in terms of producing sales using total expenses (Izah Mohd Tahir & Ku Naraini Che Ku Yusof, 2011), financial efficiency of public-listed companies using inputs of total assets, current assets, current liabilities and total expenses, current ratio, debt ratio, and debt-to-equity ratio (Ong & Anton Abdulbasah Kamil, 2010), and efficiency of *zakat* institutions in total collection of *zakat*, total distribution of *zakat* and the total number of *zakat* payers using inputs of number of staff and total expenditure (Norazlina Abd. Wahab & Abdul Rahim Abdul Rahman, 2012), and the efficiency of Penang trawl fishery (Lim, Ismail Abd Latif & Ariff Hussein, 2011).

University efficiency studies carried out in other countries include Joumady and Ris (2005) that examined the efficiency of universities in Austria, Finland, France, Germany, Italy, Netherlands, Spain and United Kingdom. Aubyn, Pina, Garcia and Pais (2009) conducted a comprehensive study on the efficiency of public spending on higher education for more than 20 developed European countries. University efficiency analysis were also carried out in other countries such as Australia (Lee, 2011), Mexico (Antonio, Domingo, Humberto, Alvaro, Alvaro & Rebeca Del Rocio (2012), Portugal (Cunha & Rocha, 2012), U.S. (Anthon, Klein & Kyle, 2010), Croatia and Slovenia (Obadic & Aristovnik, 2011), as well as the 17 European countries (Veiderpass & McKelvey, 2015). The inputs used by Veiderpass & McKelvey (2015) are similar to the present study which include expenditure, number of academic staff, and administrative staff. The marked finding of Aubyn et al. (2009) is that spending in tertiary education is related to productivity and growth if the spending is efficient. This implies that efficiency is a necessary condition for being effective in increasing productivity and growth. This clearly shows the importance of efficiency.

In Bulgaria, as revealed by Tochkov, Nenovsky and Tochkov (2012), the higher education sector has the following characteristics which are quite similar to Malaysia: private and public universities (three categories of public university: research, comprehensive and teaching), high public spending of public universities, reformation to cut public higher education funding, and searching for mechanism to allocate limited public funding on higher education. Using the input of academic staff, area, library items and research funds; output of enrolled student, starting salary and unemployment rate of graduates, and a number of publications, Tochkov, Nenovsky & Tochkov (2012) found that Bulgarian public universities are less efficient as compared to private universities, and public funding of higher education is negatively related to efficiency. The current allocation of public funding is claimed to be not based on the efficiency because it was found that

less efficient institutions were allocated larger funding as compared to the more efficient ones. The finding of Tochkov, Nenovsky & Tochkov (2012) suggested that in evaluating the efficiency of a public university, it is important to include the third party - private or overseas university as comparison.

From the literature survey, what can be observed is that most of the universities' efficiency studies, either in Malaysia or foreign countries, used teaching and research as the outputs, and academic staff, administrative staff, and public funding allocation as the inputs. Previous studies also highlight that as the efficiency measurements are relative, it is important to have a heterogeneous group of universities as a comparison group in order to make a more accurate and meaningful evaluation in this type of study.

DATA AND METHODOLOGY

Data

Data of inputs and outputs are extracted from the published annual reports of the Malaysian public universities. To ensure comparability across different universities, the data extracted are taken from the financial statements presented in the annual report. The inclusion of universities is heavily dictated by the availability of the annual report. The sample includes all the 20 public universities in Malaysia except for Universiti Malaysia Kelantan (UMK), Universiti Malaysia Sarawak (UNIMAS) and Universiti Malaysia Sabah (UMS) as their annual reports were not available at the time when this study was carried out. The sample size should be representative since 85% of the Malaysian public universities are included.

For the purpose of comparison, we include private universities in Malaysia and foreign universities from the surrounded regions of Malaysia (Southeast Asia, Asia and Oceania) that have the similar form of annual reports as the Malaysian public universities. Based on an extensive online search in these regions, we obtained the annual reports of Monash Univeristy (Monash), National University of Singapore (NUS), Chinese University of Hong Kong (CUHK), University of Waikato (Waikato), and Open University Malaysia (OUM). The universities included in this study are as follows:

1. Malaysian public university:²
 - (a) Research university: University Malaya (UM), Universiti Kebangsaan Malaysia (UKM), Universiti Putra Malaysia (UPM), Universiti Teknologi Malaysia (UTM) and Universiti Sains Malaysia (USM).

- (b) Comprehensive university: Universiti Teknologi MARA (UiTM) and Universiti Islam Antarabangsa Malaysia (UIA).
 - (c) Focused university: Universiti Pendidikan Sultan Idris (UPSI), Universiti Malaysia Perlis (UniMAP), Universiti Sains Islam Malaysia (USIM), Universiti Teknikal Malaysia Melaka (UTeM), Universiti Malaysia Pahang (UMP), Universiti Malaysia Terengganu (UMT), Universiti Sultan Zainal Abidin (UniSZA), Universiti Pertahanan Nasional Malaysia (UPNM), Universiti Tun Hussein Onn Malaysia (UTHM) and Universiti Utara Malaysia (UUM).
2. Malaysian private university: OUM.
 3. Foreign university: NUS (Singapore), CUHK (Hong Kong, China), Monash (Australia) and Waikato (New Zealand).

Thus, the sample covers 17 Malaysian public universities, one Malaysian private university and four foreign universities, from 2008 to 2011.³

The Malaysian public university's main objectives are knowledge-generating and dissemination. Thus, the appropriate choice of output should be the number of graduates produced. In addition, due to the importance of public universities to be self-financed, income generation is included as one of the outputs (income excluding government grant, and fees income). In terms of inputs, based on the production approach, universities are assumed to use the labour and non-labour inputs to produce the educational outputs. The labour inputs are academic and administrative staff; whereas the non-labour inputs are total assets, total expenditure and government operating grant.

In order to evaluate the efficiency of Malaysia public universities and also make comparison with the private and foreign universities, the analysis is performed in three stages. First, the relative efficiency among the public universities is calculated based on three groups (research, comprehensive and focused university).⁴ Second, the relative efficiency of the three most efficient public universities (selected from the first stage) and OUM (private university) is calculated. This reveals how the efficiency of the public universities changes once the private university is taken into consideration. The input slacks could be calculated as well in relation to the private university. Finally, the NUS, CUHK, Monash and Wakaito are also included into the efficiency calculation to examine how the efficiency of Malaysian universities changes when the foreign universities are taken into account.

There is a concern on the discriminatory power of the DEA. One of the rule of thumbs is that the number of DMU should be at least equal to the multiple product

of number of inputs and outputs (Bousofiane, Dyson and Thanassoulis, 1991).⁵ To meet this requirement, DEA is performed as follow: first, the university at different point of time (2008–2011) is treated as a different DMU; second, the three outputs are separated (DEA of one output with five inputs). The number of DMU is more than the multiple product of number of inputs and output (Appendix 1).

The total expenditure could be highly correlated to the number of staff. It is found that the correlation coefficients are 0.71 (academic staff) and 0.73 (administrative staff). We perform a sensitivity analysis on the estimated efficiency scores by excluding the total expenditure. There is no significant differences found on the estimated efficiency scores (Appendix 2). Since we aim to analyse the efficiency levels of the public universities based on the total spending and the outputs produced, we keep the total expenditure as one of the inputs.

METHOD

DEA (Data Envelopment Analysis) is used to measure the efficiency of public universities. The advantages of using DEA are: no functional form assumption is needed on the input-output relationship, able to handle multiple outputs and inputs, and no price information is needed. Using a mathematical programming, DEA constructs a production possibility frontier and identify the efficiency DMUs (decision making units, which in the present study, DMU refers to the university). Mathematically, the objective and constraint functions of DEA's output maximisation are as shown below:

$$\text{Maximise}_{\mu, v}: \mu' y_i$$

Subjected to:

$$v' x_i = 1$$

$$\mu' y_i - v' x_i \leq 0$$

$$\mu, v \geq 0$$

where:

$\mu = M \times 1$ vector of output weights, M =number of output

$v = K \times 1$ vector of input weights, K =number of input

$X = K \times N$ input matrix, N =number of decision making unit (DMU)

$Y = M \times N$ output matrix

$x_i =$ input vector of i^{th} DMU

$y_i =$ output vector of i^{th} DMU

The first constraint ($v'x_i = 1$) is needed to ensure no occurrence of an infinite solution problem. By duality in linear programming, a representation of input minimisation could be derived. Input slack could be calculated using the second-stage linear programming (Ali & Seiford, 1993). We used the Ji and Lee (2010)'s application to solve the DEA linear programming (implemented in STATA, version 12).

ANALYSIS AND FINDINGS

First Stage: Efficiency of Malaysian Public Universities

Research University

The efficiency analysis among the public research universities (UM, UKM, UPM, UTM and USM) is carried out using income generation excluding government grant, fees income, and graduates as outputs; and government operating grant, total expense, academic staff, administrative staff and total asset as inputs. It is found that overall, UM is the most efficient university among the research universities. This is consistent with Prathap and Ratnavelu (2015) who has found that UM performs the best in terms of productivity. This finding is also not surprising as UM is the oldest and a well-established university in Malaysia.

Table 1
Research university

	Income (exclude gov. grant)	Fees income	Graduate
	Theta ¹	Theta ¹	Theta ¹
UM	0.9508	0.9988	0.6822
UKM	0.9150	0.9343	0.8894
UPM	0.6748	0.9075	0.8420
UTM	0.3033	0.5618	0.7885
USM	0.6009	0.6729	0.7800

Note: 1. Average of theta for four years (2008–2011)

Comprehensive University

Based on the same items in outputs and inputs in the earlier analysis, efficiency test is performed on the comprehensive universities (UiTM and UIA). Results show that relatively, UiTM is more efficient than UIA in producing the outputs. Thus, UiTM is the most efficient among the comprehensive universities (Table 2). The efficiency of UiTM might be due to the large number of branches which are located throughout the nation, as compared to UIA.

Table 2
Comprehensive University

	Income (exclude gov. grant)	Fees income	Graduate
	Theta ¹	Theta ¹	Theta ¹
UiTM	0.9518	0.9701	1.0000
UIA	0.7822	0.9521	0.7620

Note: 1. Average of theta for four years (2008–2011)

Focused University

The same efficiency analysis for focused universities (UPSI, UniMAP, USIM, UTeM, UMP, UMT, UniSZA, UPNM, UTHM and UUM) is carried out. In terms of income generation and the number of graduates, UUM is clearly the most efficient university (Table 3).

Table 3
Focused university

	Income (exclude gov. grant)	Fees income	Graduate
	Theta ¹	Theta ¹	Theta ¹
UPSI	0.7884	0.8618	0.8895
UniMAP	0.4707	0.4826	0.3115
USIM	0.1894	0.2767	0.2297
UTeM	0.7529	0.3219	0.2755
UMP	0.4027	0.2985	0.2851
UMT	0.3684	0.4716	0.4893
UniSZA	0.3669	0.8172	0.6159
UPNM	0.6295	0.5962	0.5665
UTHM	0.3953	0.2847	0.3219
UUM	0.9318	0.9577	0.9244

Note: 1. Average of theta for four years (2008–2011)

Overall, results of efficiency analysis suggest that the most efficient university in the research university group is UM; in the comprehensive university group is UiTM and in the focused university group is UUM. These findings contradict Salleh (2012) which indicates that USM, UPSI and UMP are the most efficient universities during the period of 2006–2009. The difference in the outcomes could be due to the additional output in the form of income generation which is included in this study. Thus, efficiency is not only measured in the amount of graduates produced but also the abilities in income generation by the public universities.

Second Stage: Efficiency of Malaysian Public Universities Relative to Malaysian Private Universities

In the second stage, the three most efficient public universities, UM, UiTM and UUM, are selected to measure their relative efficiency against the private university (OUM) and foreign universities (NUS, Monash, CUHK and Waikato). Table 4 presents the efficiency analysis of the three public universities (UM, UiTM and UUM) and private university (OUM). If the public universities are efficient, inclusion of a private university would not change their efficiency in producing outputs using inputs as found previously in Stage 1.

Table 4
Malaysian public universities versus private university

	Output		Input slack(2008–2011) ²				
	Theta ¹	% output	Gov operating grant	Total expenditure	Acad staff	Adm staff	Total assets
	Income (exclude government grant)						
UM	0.9439	0.0561	40,500,000	77,400,000	516	918	776,000,000
UiTM	0.8769	0.1231	547,700,000	44,300,000	1,500	1,966	1,115,000,000
UUM	0.3851	0.6149	37,949,867	18,300,000	896	291	269,000,000
OUM	0.9826	0.0174	0	13,722,761	15	51	130,962,748
	Fees income						
UM	0.5224	0.4776	396,500,000	376,500,000	37	2,254	314,000,000
UiTM	0.8455	0.1545	602,000,000	116,000,350	1,216	2,326	888,000,129
UUM	0.3875	0.6125	69,300,000	20,017,352	507	395	592,855
OUM	0.9782	0.0218	0	21,150,672	24	48	212,677,793
	Graduate						
UM	0.3284	0.6716	132,496,819	656,200,000	1,315	1,853	133,900,000
UiTM	0.9813	0.0187	377,000,000	141,000,000	423	1,214	0
UUM	0.5306	0.4694	53,000,000	23,334,644	725	521	0
OUM	0.6857	0.3143	0	1	12	51	131,900,000

Note:

1. Average of theta for four years (2008–2011)
2. Sum of the four years (2008–2011) in Ringgit Malaysia.

From Table 4, OUM is found to be the most efficient in generating the fees income and income excluding government grant. This is consistent with the finding of Tochkov, Nenovsky & Tochkov (2012) where the private universities have higher efficiency scores as compared to public universities which are heavily subsidised by the government. For income excluding government grant, the result shows that

if the public universities (UM, UiTM and UUM) could be as efficient as OUM, they could generate an extra income of 5.61%, 12.31% and 61.4% for UM, UiTM and UUM respectively. As for fees income, UM, UiTM and UUM could generate an extra income of 47.76%, 15.45% and 61.25% respectively. In addition, many input slacks could be saved particularly total expenses. In terms of producing graduates, UiTM is more efficient than OUM; but UM and UUM are less efficient than OUM. In short, based on the relative efficiency in generating income, public universities are less efficient and bear higher input slacks, as compared to a private university. OUM, as private institute, has more authorities and flexibility in its resources allocation in maximising its profit (generating income).

Third Stage: Efficiency of Malaysian Universities Relative to Foreign Universities

In this stage, efficiency levels of the three public universities and one private university are compared to the four foreign universities. Table 5 presents the result of this relative efficiency analysis. Upon inclusion of the foreign universities, the relative efficiency of public university drops markedly – none of the public universities are found to be efficient in generating income. Monash and NUS are found to be the most efficient university. CUHK, Waikato and OUM have closer efficiency scores to Monash and NUS (as compared to UM, UiTM and UUM).

For income generation excluding government grant, if the Malaysian universities could be as efficient as NUS (or Monash), UM could generate an extra average income of 46.64%, UiTM is 69.89%, UUM is 72.90% and OUM is 5.75%; and for fees income, UM could generate an extra average income of 63.74%, UiTM is 68.59%, UUM is 69.23% and OUM is 6.26%. One might conclude that by referring to the efficiency levels of NUS (or Monash) in generating income, OUM is ranked as the third most efficient. Then, it is followed by UM, UiTM and UUM. In terms of input slacks (sum of 2008 to 2011), as compared to Monash and NUS, public universities have more input slack in academic staff, administrative staff, and total assets.

To ensure that the robustness of these differences, we perform a bootstrapping with 1,000 replications to estimate the 95% confidence interval of the efficiency scores. The overlapping of the estimated confidence intervals between two universities suggests that the efficiency difference (as observed in Table 5) might just occur at random, i.e., insignificant statistically. The results of this analysis is presented in Appendix 3. It is found that the efficiency of Malaysia public universities (either UM, UiTM or UUM) is lower than the private and foreign universities as what we have found in Table 5. Thus, the differences found are significant.

Table 5
Malaysian universities versus foreign universities

	Output		Input slack(2008–2011) ²				
	Theta ¹	% output	Gov operating grant	Total expenditure	Acad. staff	Adm. staff	Total assets
	Income (exclude government grant)						
UM	0.5336	0.4664	420,200,000	87,100,024	74	5,819	163,400,000
UiTM	0.3011	0.6989	539,200,000	13,300,000	1,547	8,108	1,467,900,000
UUM	0.2710	0.7290	61,100,000	0	409	990	48,448,903
OUM	0.9425	0.0575	0	16,689,758	18	26	168,800,000
Monash	1.0000	0.0000	53,540,000,000	94,400,000,000	0	0	0
NUS	1.0000	0.0000	28,790,000,000	39,800,000,000	0	0	0
CUHK	0.9020	0.0980	18,000,000	236,000,000	120	0	27,200,000
Waikato	0.9156	0.0844	45,889,542	72,062,132	0	337	0
	Fees income						
UM	0.3626	0.6374	340,700,000	187,700,000	42	4,174	214,675,826
UiTM	0.3141	0.6859	519,000,000	88,525,713	1,721	8,512	1,500,400,000
UUM	0.3077	0.6923	69,300,000	0	464	1,125	54,783,985
OUM	0.9374	0.0626	0	16,597,404	18	25	167,300,002
Monash	1.0000	0.0000	66,900,000,000	120,200,000,000	0	0	0
NUS	1.0000	0.0000	34,280,000,000	51,180,000,000	0	0	0
CUHK	0.9891	0.0109	128,000,000	0	135	0	278,000,000
Waikato	0.7333	0.2667	317,700,000	672,000,000	0	1,130	416,000,000

Note:

Average of theta for four years (2008–2011)

Sum of the four years (2008–2011) in Ringgit Malaysia.

The efficiency analysis in producing the output of graduate cannot be calculated due to the missing observation in the matrix.

DISCUSSIONS AND CONCLUSION

The present study aims to examine the efficiency among Malaysian public universities and to compare the efficiency of public universities to the private and foreign universities. Due to data limitation, the efficiency focuses only on income generation and graduates produced as the outputs; and government operating grant, total expense, academic staff, administrative staff and total asset as the inputs. On average, the most efficient Malaysian public university is UM (among research universities); UiTM (among comprehensive universities) and UUM (focused universities). Input slacks are associated to the use of government operating grant. As compared to a private university (i.e., OUM) and foreign universities (i.e., Monash and NUS), inefficiency and input slacks of public universities are shown clearly.

Public universities, either research or non-research, are not efficient in income generation. For example, UM, UiTM and UUM could produce 5.61%, 12.31% and 61.49% extra income respectively if they could be as efficient as OUM (private university) in using the inputs (academic staff, administrative staff, total assets, total expenditure and government operating grant). On the other hand, UM, UiTM and UUM could produce a respective 46.98%, 69.70% and 72.39% extra income if they could be as efficient as NUS or Monash (foreign university).

These results show that public universities in Malaysia are not efficient in generating income. Public universities face slacks in using human resource and non-human resource inputs. Generating income efficiently becomes a challenge to public universities. After depending on government grant for decades, public universities now need to re-strategise towards financial independence. The root cause of this inefficiency and input slacks could be traced back into the civil service structure in the public universities. Human resources in public universities follow civil service remuneration scale. The remuneration scale is fixed and public universities have less choices in providing incentives to retain and attract talented staff for efficiency improvement. In addition, the cost centre structure of public universities might lead to inefficient use of resources (inputs). This creates another challenge on how can the public university's system be re-structured for efficiency.

Government funding is the most important financial input of public universities and slacks occur in using this government funding to generate income and to produce graduates. Although the estimated figure is purely mathematical (without taking into consideration of other factors such as corporate social responsibility), this figure still highlights the importance of improving efficiency of public universities in using the public funds.

In order to obtain a better estimation in efficiency of public universities, we need a better data in terms of consistency, transparency and comparability. The current input and output data of universities in Malaysia, public as well as private, are still lacking and inconsistent. In addition, the selection of comparison universities (foreign and private) is largely based on the availability of online annual report, future studies are suggested to explore further using more comparison universities. There is a need to improve the quantity and quality of inputs and outputs data of universities in Malaysia.

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NOTES

- 1 In DEA, the input slack refers to the situation where the amount of input used in a production process could be reduced without reducing the amount of output produced (Coelli, Rao, O'Donnell & Battese, 2005).
- 2 The Malaysian public universities is categorised by the Ministry of Higher Education into three groups. First, the research universities that focus on research, competitive in student entries, quality lecturers and equal ratio of undergraduates to postgraduate. Second, the comprehensive universities that offer a variety of courses and fields of study, competitive in student entries, quality lecturers and ratio of undergraduates to postgraduate is 70:30. Finally, the focused universities that concentrate on specific fields related to its establishment, competitive in student entries, quality lecturers and equal ratio of undergraduates to postgraduate (Public Institutions of Higher Education, 2016).
- 3 For foreign universities, their currencies are converted into Ringgit Malaysia using the exchange rate of the respective year (source: <http://www.nzforex.co.nz>):
 - New Zealand (RM/NZD): 2.37 (2008), 2.27 (2009), 2.32 (2010), 2.42 (2011)
 - Hong Kong, China (RM/HKD): 0.43 (2008), 0.45 (2009), 0.41 (2010), 0.39 (2011)
 - Singapore (RM/SGD): 2.35 (2008), 2.43 (2009), 2.36 (2010), 2.43 (2011)
 - Australia (RM/AUD): 2.83 (2008), 2.82 (2009), 2.96 (2010), 3.16 (2011)
- 4 The DEA is applied into universities in these three groups separately and obtained the most efficient university. Thus, the efficient university obtained from the local frontier, instead of global frontier (which includes all university in the DEA). We have attempted to include all universities, however, it is failed to obtain the optimisation in the linear programming. Since the universities are

grouped into the categories based on similarities of certain criterions, some level of homogeneity should be there. Thanks to the anonymous referee for point out this issue.

- 5 There are other rule of thumbs which are more restrictive. For example, Golany and Roll (1989) suggest that in a DEA, the number of DMU should be at least twice the sum of the number of output and input.

APPENDIX 1

The number of DMU and sum of product of output and input

	The number of:				
	Separated DEA of:	Input (I)	Output (O)	$I \times O$	DMU
<u>Stage 1</u>					
Research university ¹	1 (output: income)	5	1	5	20
	2 (output: fees)	5	1	5	20
	3 (output: graduate)	5	1	5	20
Comprehensive university ²	1 (output: income)	5	1	5	8
	2 (output: fees)	5	1	5	8
	3 (output: graduate)	5	1	5	8
Focused university ³	1 (output: income)	5	1	5	40
	2 (output: fees)	5	1	5	40
	3 (output: graduate)	5	1	5	40
<u>Stage 2</u>					
Private university ⁴	1 (output: income)	5	1	5	16
	2 (output: fees)	5	1	5	16
	3 (output: graduate)	5	1	5	16
<u>Stage 3</u>					
Private & foreign university ⁵	1 (output: income)	5	1	5	32
	2 (output: fees)	5	1	5	32
	3 (output: graduate)	5	1	5	32

Note:

1. Five research universities (5) \times four years (2008–2011) = 20 (DMUs)
2. Two comprehensive universities (2) \times four years (2008–2011) = 8 (DMUs)
3. Ten focused universities (10) \times four years (2008–2011) = 40 (DMUs)
4. Four universities (3 public and 1 private universities) \times four years (2008–2011) = 16 (DMUs)
5. Eight universities (3 public, 1 private and 4 foreign universities) \times four years (2008–2011) = 32 (DMUs)

APPENDIX 2

Sensitivity analysis on excluding total expenditure

	All input			Exclude total expenditure		
	Income (exclude gov. grant)	Fees income	Graduate	Income (exclude gov. grant)	Fees income	Graduate
	Theta ¹	Theta ¹	Theta ¹	Theta ¹	Theta ¹	Theta ¹
Research university						
UM	0.9508	0.9988	0.6822	0.9488	1.0000	0.6822
UKM	0.9150	0.9343	0.8894	0.9326	0.9393	0.8894
UPM	0.6748	0.9075	0.8420	0.6730	0.8983	0.8420
UTM	0.3033	0.5618	0.7885	0.2729	0.4869	0.7885
USM	0.6009	0.6729	0.7800	0.6110	0.6639	0.7794
Comprehensive university						
UiTM	0.9518	0.9701	1.0000	0.9395	0.9554	1.0000
UIA	0.7822	0.9521	0.7620	0.7910	0.9370	0.7614
Focused university						
UPSI	0.7884	0.8618	0.8895	0.7983	0.8814	0.8900
UniMAP	0.4707	0.4826	0.3115	0.4638	0.4790	0.3022
USIM	0.1894	0.2767	0.2297	0.1918	0.2778	0.2237
UTeM	0.7529	0.3219	0.2755	0.7466	0.3167	0.2756
UMP	0.4027	0.2985	0.2851	0.3985	0.3004	0.2851
UMT	0.3684	0.4716	0.4893	0.3689	0.4681	0.4869
UniSZA	0.3669	0.8172	0.6159	0.3645	0.8266	0.6159
UPNM	0.6295	0.5962	0.5665	0.6289	0.6009	0.5645
UTHM	0.3953	0.2847	0.3219	0.3945	0.2829	0.3209
UUM	0.9318	0.9577	0.9244	0.9224	0.9477	0.9163

Note: 1. Average of theta for four years (2008–2011)

How Efficient are Malaysian Public Universities?

	All input			Exclude total expenditure		
	Income (exclude gov. grant)	Fees income	Graduate	Income (exclude gov. grant)	Fees income	Graduate
	Theta ¹	Theta ¹	Theta ¹	Theta ¹	Theta ¹	Theta ¹
UM	0.9439	0.5224	0.3284	0.9401	0.5977	0.3444
UiTM	0.8769	0.8455	0.9813	0.8664	0.8405	0.9772
UUM	0.3851	0.3875	0.5306	0.3737	0.3813	0.5313
OUM	0.9826	0.9782	0.6857	0.9297	0.9247	0.6629

Note: 1. Average of theta for four years (2008–2011)

	All input		Exclude total expenditure	
	Income (exclude gov. grant)	Fees income	Income (exclude gov. grant)	Fees income
	Theta ¹	Theta ¹	Theta ¹	Theta ¹
UM	0.5336	0.3626	0.5287	0.3626
UiTM	0.3011	0.3141	0.2954	0.3092
UUM	0.2710	0.3077	0.2602	0.3005
OUM	0.9425	0.9374	0.9297	0.9247
Monash	1.0000	1.0000	1.0000	1.0000
NUS	1.0000	1.0000	1.0000	1.0000
CUHK	0.9020	0.9891	0.9020	0.9874
Waikato	0.9156	0.7333	0.9156	0.7333

Note: 1. Average of theta for four years (2008–2011)

APPENDIX 3

Malaysian universities versus foreign universities: Hypothesis tests on the efficiencies differences

Bootstrapping (95% confidence interval)							
	UM vs others	UiTM vs others	UUM vs others	OUM vs others	Monash vs others	NUS vs others	CUHK vs others
<u>Income (exclude government grant)</u>							
UM	-	-	-	-	-	-	-
UiTM	Sig (UM>UiTM)	-	-	-	-	-	-
UUM	No	No	-	-	-	-	-
OUM	Sig (UM<OUM)	Sig (UiTM<OUM)	Sig (UUM<OUM)	-	-	-	-
Monash	Sig (UM<Monash)	Sig (UiTM<Monash)	Sig (UUM<Monash)	-	-	-	-
NUS	Sig (UM<NUS)	Sig (UiTM<NUS)	Sig (UUM<NUSM)	No	Sig (Monash>NUS)	-	-
CUHK	Sig (UM<CUHK)	Sig (UiTM<CUHK)	Sig (UUM<CUHK)	No	No	Sig (NUS<CUHK)	-
Waikato	Sig (UM<Waikato)	Sig (UiTM<Waikato)	Sig (UUM<Waikato)	No	No	No	No
<u>Fees income</u>							
UM							
UiTM	Sig (UM>UiTM)	-	-	-	-	-	-
UUM	Sig (UM<OUM)	Sig (UiTM<UUM)	-	-	-	-	-
OUM	Sig (UM<OUM)	Sig (UiTM<OUM)	Sig (UUM<OUM)	-	-	-	-
Monash	Sig (UM<Monash)	Sig (UiTM<Monash)	Sig (UUM<Monash)	No	-	-	-
NUS	Sig (UM<NUS)	Sig (UiTM<NUS)	Sig (UUM<NUS)	Sig (OUM>NUS)	Sig (Monash>NUS)	-	-
CUHK	Sig (UM<CUHK)	Sig (UiTM<CUHK)	Sig (UUM<CUHK)	No	No	No	-
Waikato	Sig (UM<Waikato)	Sig (UiTM<Waikato)	No	Sig (OUM>Waikato)	Sig (Monash>Waikato)	No	Sig (CUHK>Waikato)

Notes:

1. The bootstrapping of DEA is performed for 1,000 replication and 95% confidence interval is estimated based on the 1,000 estimate of theta (efficiency score).
2. "Sig" means there is no overlapping between the estimated confidence interval of the two universities. Thus, a significant difference is found statistically (two population mean differences test using confidence interval approach).
3. "No" means there is overlapping between the estimated confidence interval of the two universities. Thus, no significant difference is found statistically (two population mean differences test using confidence interval approach)

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