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Relative Efficiency of Public Universities in Malaysia

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Abstract: This paper examines the relative efficiency of 20 public universities of Malaysia in the students' transition process in 2011.Three input and five output values are defined to estimate the relative efficiency of the universities through the marketability of the graduated students; either they manage to get a job, or further their studies or being unemployed. Data were gathered from Ministry of Higher Education in Malaysia and Ministry of Education Graduate Tracer Study websites. Data Envelopment Analysis (DEA) is used to measure the relative efficiency of the universities as well as rank and benchmark them. The results of applying DEA models in Constant Returns to Scale (CRS) and Variable Returns to Scale (VRS) show that University Technology MARA is the most efficient university in Malaysia followed by University Malaysia Terengganu and University of Malaya.
Keywords: Data envelopment analysis, Kourosh and Arash model, Efficiency, Ranking, University.

INTRODUCTION

Higher Education Institutions (HEIs) is the knowledge based institutions that offer chances to the citizens to continue their study at the higher level. There are many categories of HEIs in Malaysia such as Public Universities (PUs), Private Universities (PIs), Community Colleges (CCs), Polytechnics and Skill Colleges (PSCs).The huge number of HEIs established in Malaysia show how serious the government wants to provide enough places for Malaysian and even for foreigners to study. It also shows how important the knowledge and skills for achieving the highest standard of education level by making a reality of Malaysia's Vision 2020. The essential part of HEIs is to develop and create a quality and knowledgeable graduates based on government's mission and vision. Every HEIs administration in Malaysia need to set targets and fill their students with sufficient knowledge and foster soft skills. Basically, this is to give the community with a high quality of student after graduation.

HIEs are usually regulated by ministry of higher education in Malaysia. There are 20 public universities that being operate with public funds and government assists. Public universities are still the leading of higher education in Malaysia. In the recent years, 5 of Malaysia top public universities manage to get place in the British Quacquarelli Symonds (QS)World University Rankings. QS Rankings are one of the three most influential university system beside the Time Higher Education (THE) world university rankings and Academic Ranking of World Universities (ARWU)[1].

In this paper, the relative efficiencies of 20 Malaysia's public universities are examined through a transition process of students. This is to identify which university produces more quality students based on demand in the job market. The efficiencies of universities are evaluated through the student's status after been graduated; either they manage to get a job, or further their studies or being unemployed.

8 factors inclusive 3 inputs and 5 outputs are considered to apply Data Envelopment Analysis (DEA) models. DEA is a common nonparametric method which measures the performance evaluation of a set of homogenous Decision making Units (DMUs). It gives an efficiency score between 0 and 1 for each DMU, and shows the potential increase or decrease of each selected factors. DEA was proposed by Charnes *et al.* [2] and has sharply been developed in many contexts and area. A recent robust model in DEA, called Kourosh and Arash Model (KAM) [3] is applied to rank and benchmark the universities appropriately. KAM increases the discrimination power of DEA uniquely.

The rest of this paper is organized in 5 sections. Section 2 is literature review. Section 3 describes data and the results and interpretation of applying DEA models are illustrated in Section 4. Section 5 concludes the paper.

LITERATURE REVIEW

Many researches have been done on measuring relative efficiency of universities in recent years. Efficiency in higher learning institutions refers to which institutions allocate efficiently the inputs available to generate the given level of output. Higher learning institution's efficiency involves the combination of multiple inputs to produce multiple outputs.

Universities employ academic staffs to educate the students to produce graduates with certain level of quality. Thus, teaching efficiency is referring to the teaching performance of universities in delivering knowledge to undergraduate and postgraduate students. The quality of students is taken as an input based on a general assumption that better entry qualifications will produce better quality graduates. The outputs of teaching activities are concentrated on graduates. Graduates' results and graduation rate of a university are associated with the academic quality of graduates; while graduates' employment rate is reflecting the employers' perception on the quality of graduates from a particular university.

Table 1 illustrates a summary of some of the most recent empirical studies using DEA to assess higher education efficiency in several countries.

Moreover, Breu and Raab[4]also used DEA Variable Returns to Scale (VRS) to measure the relative efficiency of the top 25 US universities. Outputs used were graduation rate and freshman retention rate as measures of student satisfaction. Inputs percentage faculty with doctorates, faculty to student ratio, and educational and general expenditures per student. Kokkelenberg *et al*. [5] measured the efficiency of 753 private universities in United States for the period of 1997 until 2003 by graduation rates as the major output through Ordinary Least Squares (OLS) and Stochastic Frontier Analysis (SFA). Their findings indicated that universities with high prestige and reputation did not necessarily produce higher student satisfaction and quality. In the recent work in 2014,Bangi[6] discussed about two-stage DEA model by examines the efficiency of private Universities in Tanzania in 2008-2012.

Among the major problem in the evaluation of efficiency of local higher learning institutions, is the selection of input and output variables for the model. The comparative evaluation is focused on ratio analysis that allows initial comparisons to be made and some early conclusions to be reached based on performance indicators. These indicators reflect mainly on human resources involved in supporting institutional services and the quantity of outcomes produced.

There are many different forms of efficiency that can be estimated according to economists; four of which are most often use in the context of higher education institutions are technical efficiency, allocative or price efficiency, economic or overall efficiency and scale efficiency. Intuitively technical efficiency is a measure of the extent to which institutions efficiently allocate the physical inputs at its disposal for a given level of output. In other words, technical efficiency refers to the use of productive resources in the most technologically efficient manner. According to Worthington [7] "…technical efficiency refers to the physical relationship between the resources used (say, capital, labor and equipment) and some education outcome".

Charnes, Cooper and Rhodes model (CCR) is the first traditional DEA model to measure technical efficiency of DMUs in Input (Output) Oriented developed in 1978 by Charnes *et al.*[2]. Banker *et al.*[8] introduce Banker, Charnes and Cooper model (BCC) to measure the technical efficiency in VRS. Weighted Additive model (ADD)[9], Slack Based Measure (SBM), model are the two non-radial DEA models which simultaneously consider both input and output orientation. However, none of these models are able to discriminate between technically efficient DMUs. There are some DEA models called Super-efficiency models which are not able to rank technically efficient DMUs appropriately [10].

Table 1: Some of the recent efficiency studies on universities.

Author, Year	**Method**	**DMUs**	**Inputs**	**Outputs**
Abbott and Doucouliagos[11]	Technical and Scale Efficiency	36Australian Government universities	- Number of academic staff, - Number of non-academic staff, - Expenditure, - Value of non-current asset.	- Number of full time students, - Research Quantum Allocation, - Medical and non-medical research income.

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Flegg et al. [12]	Technical and Scale Efficiency, Congestion	45 British Universities in the period 1980-1993	- Number of staff, - Number of undergraduate students, - Number of postgraduate students, - Aggregate departmental expenditure.	- Income from research and consultancy, - The number of undergraduate degrees awarded, - The number of postgraduate degrees awarded.
Katharaki and Katharakis[13]	CRS-IO	20 Public Universities in Greece.	- Number of academic staff, - Number of non-academic staff, - Number of active registered students, - Operating expenses.	- Total number of graduate students, - Research income.
Daghbashyan[14]	CCR BCC	47 Royal Institute of Technology, Sweden (2007)	- Number of professors, - Research staff, - PhD students, - Technical-administrative staff.	- Number of journal papers, - Number of review papers, - Number of conference papers, - Number of authored books.
Liu et al. [15]	Super efficiency Tobit Regression	40 teacher's college in Thailand.	- Number of teachers, - Number of students, - Number of full time staffs, - Number of part time staffs.	- Number of publications, - Number of graduated students, - Number of employed students.
Kipesha and Msigwa[16]	CCR BCC	7 Public Universities in Tanzania.	- Total enrolment, - Total academic staffs, - Total non-academic staffs, - Total staffs.	- Number of undergraduate graduates, - Number of postgraduate graduates, - Total graduates.

Khezrimotlagh et al. [3] proposed a robust model based on ADD and SBM, called KAM which is appropriately able to rank and benchmark technically efficient DMUs. KAM measures the relative efficiency of each DMU while a very small negligible thickness of the frontier is introduced. The ε-KAM is as follows:

$$\max \sum_{j=1}^{m} w_j^- s_j^- + \sum_{k=1}^{p} w_k^+ s_k^+$$

Subject to

$$\sum_{i=1}^{n} \lambda_i x_{ij} + s_j^- = x_{lj} + \varepsilon_j^-, \text{ for } j = 1,2,\dots,m,$$
$$\sum_{i=1}^{n} \lambda_i y_{ik} - s_k^+ = y_{lj} - \varepsilon_k^+, \text{ for } k = 1,2,\dots,p,$$
$$\lambda_i \geq 0, \text{ for } i = 1,2,\dots,n,$$
$$s_j^- \geq 0, \text{ for } j = 1,2,\dots,m,$$
$$s_k^+ \geq 0, \text{ for } k = 1,2,\dots,p.$$

The KAM best technical efficient target and score with ε degree of freedom (ε-DF) are as follows, respectively:

$$\begin{cases} x_{lj}^* = x_{lj} - s_{lj}^{-*} + \varepsilon_j^-, \text{for } j = 1,2,\dots m, \\ y_{lk}^* = y_{lk} + s_k^{+*} - \varepsilon_k^+, \text{for } k = 1,2,\dots p. \end{cases}$$

$$KA_\varepsilon^{*l} = \frac{\sum_{k=1}^{p} w_k^+ y_{lk} \,/\, \sum_{k=1}^{p} w_j^- x_{lj}}{\sum_{k=1}^{p} w_k^+ y_{lk}^* \,/\, \sum_{k=1}^{p} w_j^- x_{lj}^*}$$

The weights are defined as $w_j^- = 1/x_{lj}$ and $w_k^+ = 1/y_{lk}$, where $x_{lj} > 0$ and $y_{lk} > 0$, and if $x_{lj} = 0$ or $y_{lk} = 0$, the weights are defined as 1. Moreover, the components of epsilon vector, ε_j^- and ε_k^+, are defined as $\varepsilon \times \min\{x_{ij} : x_{ij} \neq 0, i = 1,2,\dots,n\}$ and $\varepsilon \times \min\{y_{ik} : y_{ik} \neq 0, i = 1,2,\dots,n\}$, respectively, where ε is a nonnegative real number. The value of ε is considered as a very small positive real number in order to have a negligible thickness in the frontier. A technically efficient DMU is called efficient with ε-DF if $1 - KA_\varepsilon^* < \delta$, otherwise, it is called inefficient with ε-DF. The value of δ depends on the aim of measuring the efficiency scores of DMUs and would be defined by $\varepsilon/(m+p)$ or $\varepsilon/10$ or less/greater value to have at least one efficient DMU with ε-DF in the sample. If the value of epsilon is 0, KAM is the same as ADD, and is almost completely the same as the non-linear SBM.

Data Selection

Table 2 illustrates 20 public universities of Malaysia and their abbreviations.

Table 2: The Public Universities of Malaysia.

University	Code	University	Code
University Malaya	UM	University Technology MARA	UITM
University Science Malaysia	USM	University Sultan Zainal Abidin	UNISZA
University Kebangsaan Malaysia	UKM	University Malaysia Terengganu	UMT
University Putra Malaysia	UPM	University Science Islam Malaysia	USIM
University Technology Malaysia	UTM	University Tun Hussein Onn Malaysia	UTHM
University Utara Malaysia	UUM	University Technical Melaka	UTEM
University Islam Antarabangsa Malaysia	UIAM	University Malaysia Pahang	UMP
University Malaysia Sarawak	UNIMAS	University Malaysia Perlis	UNIMAP
University Malaysia Sabah	UMS	University Malaysia Kelantan	UMK
University Perguruan Sultan Idris	UPSI	University PertahananNational Malaysia	UPNM

In order to measure the relative efficiency of these 20 universities, 3 inputs and 5 outputs are selected as shown in Table 3.

The data of selected factors were collected from two major sources which were Ministry of Higher Education in Malaysia [17] and websites of the Ministry of Education (MOE) Graduate Tracer Study [18]. Table 4 represents the data of each factors.

Table 3: The selected inputs and outputs.

Inputs	Outputs
Number of Postgraduate students enrolled	Number of Postgraduate graduates
Number of Undergraduate students enrolled	Number of Undergraduate graduates
Number of Academic Staff	Number of graduates working
	Number of graduates opt for further studies
	Number of graduates opt for developing skills

Table 4: Data of Universities in 2011.

DMUs	Input 1	Input 2	Input 3	Output 1	Output 2	Output 3	Output 4	Output 5
UM	2471	3502	2076	1799	4127	3813	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	28223	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

The Results of DEA models

Table 5 shows the efficiency score of applying CCR IO, CCR OO, BCC IO, BCC OO, ADD CRS, ADD VRS, 10^{-6} KAM CRS and 10^{-6} KAM VRS.

In order to apply KAM, the weights are defined as $w_j^- = 1/x_{lj}$ and $w_k^+ = 1/y_{lk}$ for each factor of evaluated DMU, except for 20^{th} DMU (UPNM) that has

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zero value for the first output and w_1^+ is defined as 1 in this case. The value of epsilon is selected as 10^{-6}, because the nonzero minimum value for factors are 15, 580, 213, 1, 266, 137, 6 and 6 respectively [19-20]. Therefore, the components of epsilon vector are 0.000015, 0.000580, 0.000213, 0.000001, 0.000266, 0.000137, 0.000006 and 0.000006 which are completely negligible according to each factor. Indeed, KAM consider an efficient tape instead the estimated efficient frontier which means considering a very negligible thickness of the estimated frontier.

There are 11 technically efficient DMUs with both CRS and VRS models. UMK is totally inefficient in CRS while it is technically efficient in VRS. The most efficient DMUs are UITM, UMT and UM followed by UUM, UIAM and UPM. Universities UNIMAS, USM, USIM, UTHM, UTEM, UTM, UMP and UNIMAP are inefficient in both CRS and VRS.

Although, UMK is a technically efficient in VRS, it is the worst inefficient university in CRS. The last four columns of Table 5 show how KAM arranges all DMUs with 10^{-6}-DF. Indeed, KAM by introducing a very small negligible thickness in the estimated efficient frontier appropriately discriminate DMUs.

Table 6 illustrates the reference sets of each technically and inefficient DMUs which are measured based on the nonzero optimum values of lambdas by KAM with 10^{-6}-DF. Moreover, by introducing δ as $\varepsilon/10$, KAM CRS suggests that UITM and UMT are efficient with 10^{-6}-DF. KAM VRS also suggests UITM, UMT and UM as efficient with 10^{-6}-DF. Other technically efficient universities are inefficient with 10^{-6}-DF in inputs and outputs in both CRS and VRS. Moreover, UITM is a reference set for almost all universities in the sample. Even if the components of epsilon vector, ε_j^- and ε_k^+, are defined as $\varepsilon \times x_{lj}$ and $\varepsilon \times y_{Lk}$, KAM suggests UITM as the most efficient university in the sample with 10^{-6}-DF followed by UMT and UM.

Table 5: The results of DEA models in CRS and VRS.

DMUs	CCR-IO (OO)	BBC-IO	BBC-OO	ADD CRS	ADD VRS	10^{-6} KAM CRS	Rank	10^{-6} KAM VRS	Rank
UM	1	1	1	1	1	0.9999998	3	1	1
USM	0.7221	0.7303	0.7324	0.3678	0.3772	0.3677889	18	0.3772225	19
UKM	1	1	1	1	1	0.9999997	7	0.9999997	7
UPM	1	1	1	1	1	0.9999997	6	0.9999999	4
UTM	0.7319	0.7668	0.7457	0.5098	0.5138	0.5097503	14	0.5138244	16
UUM	1	1	1	1	1	0.9999998	4	0.9999998	5
UIAM	1	1	1	1	1	0.9999998	5	0.9999998	6
UNIMAS	0.7194	0.7222	0.7582	0.2623	0.2643	0.2623395	19	0.2643339	20
UMS	1	1	1	1	1	0.9999992	8	0.9999995	8
UPSI	1	1	1	1	1	0.9999728	11	0.9999744	11
UITM	1	1	1	1	1	1	1	1	1
UNISZA	1	1	1	1	1	0.999996	9	0.9999961	9
UMT	1	1	1	1	1	1	1	1	1
USIM	0.8674	0.8707	0.8873	0.4206	0.4386	0.4205728	17	0.4385551	18
UTHM	0.6534	0.7298	0.6639	0.4304	0.4517	0.4303866	16	0.4516933	17
UTEM	0.5481	0.6354	0.5517	0.4980	0.5353	0.4980229	15	0.5353424	15
UMP	0.8911	0.9098	0.9143	0.6024	0.5574	0.6024385	13	0.5574062	14
UNIMAP	0.8397	0.8886	0.9229	0.7201	0.6839	0.7201332	12	0.6838664	13
UMK	0.3123	1	1	0.0586	1	0.0585951	20	0.9959415	12
UPNM	1	1	1	1	1	0.9999945	10	0.9999956	10

Table 6: KAM decision and reference sets.

DMUs	KAM CRS Decision and Reference Sets		KAM VRS Decision and Reference Sets	
UM	Inefficient with 10^{-6}-DF	UM, UUM, UITM	Efficient with 10^{-6}-DF	UM
USM	Inefficient	UM, UUM, UIAM, UITM	Inefficient	UM, UUM, UIAM, UITM
UKM	Inefficient with 10^{-6}-DF	UM, UKM, UITM	Inefficient with 10^{-6}-DF	UM, UKM, UITM, UPNM
UPM	Inefficient with 10^{-6}-DF	UM, UPM, UUM, UITM	Inefficient with 10^{-6}-DF	UM, UPM, UITM
UTM	Inefficient	UM, UUM, UIAM, UITM	Inefficient	UM, UUM, UIAM, UITM,UPNM
UUM	Inefficient with 10^{-6}-DF	UUM, UITM, UMT	Inefficient with 10^{-6}-DF	UUM, UITM
UIAM	Inefficient with 10^{-6}-DF	UIAM, UITM, UMT, UPNM	Inefficient with 10^{-6}-DF	UIAM, UITM, UPNM
UNIMAS	Inefficient	UITM, UNISZA, UMT, UPNM	Inefficient	UUM, UITM, UMT, UPNM
UMS	Inefficient with 10^{-6}-DF	UMS, UITM, UMT	Inefficient with 10^{-6}-DF	UMS, UITM, UMT
UPSI	Inefficient with 10^{-6}-DF	UUM, UPSI, UMT	Inefficient with 10^{-6}-DF	UUM, UMS, UPSI,
UITM	Efficient with 10^{-6}-DF	UITM, UPNM	Efficient with 10^{-6}-DF	UITM
UNISZA	Inefficient with 10^{-6}-DF	UNISZA, UMT	Inefficient with 10^{-6}-DF	UNISZA, UMT
UMT	Efficient with 10^{-6}-DF	UMT, UPNM	Efficient with 10^{-6}-DF	UMT, UPNM
USIM	Inefficient	UIAM, UMS, UITM, UMT, UPNM	Inefficient	UIAM, UMS, UITM, UPNM
UTHM	Inefficient	UUM, UITM	Inefficient	UUM, UITM, UPNM
UTEM	Inefficient	UUM, UITM	Inefficient	UUM, UITM, UMT, UPNM
UMP	Inefficient	UITM, UMT, UPNM	Inefficient	UITM, UMT, UPNM
UNIMAP	Inefficient	UITM, UNISZA, UMT, UPNM	Inefficient	UITM, UMT, UPNM
UMK	Inefficient	UUM, UITM	Inefficient with 10^{-6}-DF	UUM, UMK, UPNM
UPNM	Inefficient with 10-6-DF	UMT, UPNM	Inefficient with 10^{-6}-DF	UMT, UPNM

CONCLUSION

This paper estimates which Malaysia's universities produce more quality students based on demand in the job market through the student's status after been graduated; either they manage to get a job, or further their studies or being unemployed. A robust KAM discriminates the most efficient universities of Malaysia as well as rank and benchmark each university. Increasing the number of factors and improving the appropriate way of gathering data can be a guideline for future researches.

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