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Performances of academic departments using data envelopment analysis (DEA) approach

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ABSTRACT

Universities are the backbone of a country's development. Public universities are subsidised by the government, with funds coming from taxpayers' contributions. It is therefore important that public universities utilise their resources efficiently. This study evaluates the performance of five academic departments for the period 2016-2018. The tool used to evaluate efficiency is Data Envelopment Analysis (DEA) with CCR output-oriented model using a software DEA-Solver-LV version 8. The secondary data of the three input variables are the number of academic staff, the number of non-academic staff and capital grants. The three output variables used in this study are the number of publications, the number of PhD students and the number of undergraduate graduates. The results show that the departments that are really efficient in the years 2016 to 2018 are the academic departments B and E. The average efficiency score from 2016 to 2018 is 0.972436, 1.0000 and 0.990989, respectively, which shows that the performance of departments in general has been somewhat inconsistent over the three years.

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1. INTRODUCTION

An important problem in assessing the efficiency of higher education institutions is the aggregation of heterogeneous inputs and outputs [1]. In addition, measuring the efficiency and productivity of public universities provides an indirect assessment of the management of public resources, as public universities are among the largest users of national resources [2]. Moreover, with the growing number of students in public universities and limited financial resources, it is no longer possible for these institutions to operate with a higher level of efficiency.

Universities, or higher education institutions and tertiary education institutions, are knowledge organisations [3]. Universities are divided into two sectors: the public sector and the private sector. Private sector universities are highly competitive and profit-orientated, while the activities of public sector universities are not subject to this pressure [4]. Public universities have a limited amount of funds from the public budget, which are distributed and monitored on the basis of a detailed regulation [4]. More efficient utilisation of resources is essential due to diminishing government subsidies [5]. As the number of universities has rapidly and extremely increased [6], universities need to perform higher research and promote academic excellence as some of them are funded based on their performance level [7].

Evaluating efficiency is essential for a university to allocate and utilise educational resources effectively [8]–[10]. To improve its efficiency, a performance evaluation tool is needed to measure the performance of the entire university [10]. Academic departments must focus on teaching, research or scholarship to fulfil the university's mission [11]. Universities are complex organisations as they use a variety of inputs to produce a variety of outputs. Therefore, it is a difficult task to evaluate their efficiency, which may affect the long-term planning of a country [6]. There are numerous studies on the efficiency of the performance of university departments. However, in the Asian region, there is a lack of studies on the performance of universities using the DEA model [10].

A university must meet certain criteria mentioned earlier to be recognised as the best university in the world. Therefore, it is important to know which side of the bread you are on. A university must be able to differentiate between efficient and inefficient faculties in order to compensate for the lack of performance of the university as a whole. Since DEA is a powerful tool [12] that can handle multi-dimensional problems with multiple inputs and outputs and avoids the difficulty of deciding on potentially unequal weightings of the criteria [2], this study uses Data Envelopment Analysis (DEA) to determine the performance of academic faculties.

Efficiency

Debrau (1951), Koopmans (1951) and Farrell (1957) were the first to empirically measure the efficiency of production units (cited in [1]). Meanwhile, productivity is simply the ratio between output and input [9]. To measure the efficiency of a production unit, it is therefore necessary to compare input and output [13]. It is helpful for university managers to know the effectiveness of different units and to better allocate human and financial resources [7]. Consequently, the performance efficiency of universities should be improved and continuously monitored to fulfil the intellectual standard of the university, which ensures that qualified manpower and research are produced efficiently [11].

Data Envelopment Analysis (DEA)

DEA is a non-parametric method [9]. It is used to evaluate the efficiency of homogeneous or similar production [13]. It is an alternative to multivariate statistical methods for data with multiple inputs and outputs [14]. DEA is a single-measure approach that is ideal for analysing the relative efficiency of units that require multiple resources in their production process to produce the different types of products [15]). It is used to measure the efficiency of decision making units (DMUs) and compare the inefficient unit with its best peers or also known as the efficiency frontier [2], [16]. Decision-making units (DMUs) are a set of equivalent units that use similar inputs and produce similar outputs to be evaluated [17]. However, the most efficient unit, which has a score of one, does not necessarily produce the maximum level of outputs from the given input, but it produces the best practise level of output among the other units [2].

Decision Making Unit (DMU)

DEA is a non-parametric approach to evaluate the relative efficiency of decision making units (DMUs) [18]. DMUs should transform inputs into outputs, as inefficient departments should adopt the strategies and techniques of their benchmarks in the production process [5]. DEA aims to find the DMUs that produce the highest outputs with the lowest inputs, such as multi-product companies that convert resources into products [19]. Conventional DEA models do not take into account the internal structure of decision making units (DMUs) [20]. Several methods have been developed to first find the set of efficient DMUs to reduce the number of decision variables by removing the decision variables associated with inefficient DMUs. Then, the desired DEA model is applied to measure the performance of the remaining inefficient DMUs [21]. The decision making units (DMUs) for this study are five academic departments of the university.

The input and output variables

There are no definitive standards to guide the selection of input and output criteria for evaluating university efficiency [10]. Nevertheless, there are difficulties in selecting the variables due to the availability of the data to be considered, with some of the data being difficult to obtain [5]. Therefore, the input and output variables were selected based on the most common meta-analysis of 10 journals [2], [4]–[6], [9], [10], [12],

[13], [19], [22]. Figure 1 shows the inputs and outputs selected for this study. Although operating costs and government budget support have received much attention from the authors, they will not be included among the input variables because they are difficult to obtain for this study. The explanation for each variable is as follows.

Input variables

a. Number of academic staff

This input is an indicator of human capital. Academic staff are the most important providers of expertise at universities. In each department, the role of academic staff is both teaching and research [6]. Teaching is the first task of all departments and is related to academic staff [23]. The number of students should be proportional to academic staff, which is consistent with the established student-staff ratios in different universities.

b. Number of undergraduate students admitted/number of students in courses

This figure is an indicator of human capital. A person who has completed an undergraduate degree and has been admitted to a graduate programme [5]. In most departments, two types of students are enrolled: undergraduates and postgraduates, while in some departments only undergraduates are enrolled [23].

c. Teacher/student ratio

The teacher-student ratio is the ratio between the number of students and the number of full-time teachers. The ideal teacher-student ratio is 1:30, i.e. 1 lecturer for 30 students.

Output variables

a. Number of publications

Research represents the number of publications of a university. In addition to teaching, academic staff are also expected to publish in journals, write books and give presentations at conferences [6]. Research publications are one of the most important research activities of a faculty. Therefore, authors are considered as outputs for research effectiveness, which include book/chapters in books/monographs, papers in journals and papers at conferences/symposia [23].

b. Number of graduate students/graduation rate

The graduation rate is the total number of enrolled undergraduate and postgraduate students who have left the university (in %). The graduation rate of students in a department is related to the academic quality of doctoral students [24].

c. Employment rate of graduates

Graduate employment rate is the rate of students hired and shows how recruiters rate the quality of graduates from a particular university [24]. Other relevant issues include encouraging economic growth to absorb graduates and determining whether graduates are versatile and can adapt to changes in the labour market [25].

d. Total amount of research funding

Grants represent the total amount of financial resources. In line with the University's aim, all academic staff are expected to undertake research. The total amount of research funding, which includes internal and external funds, reflects the research activity of the department [9].

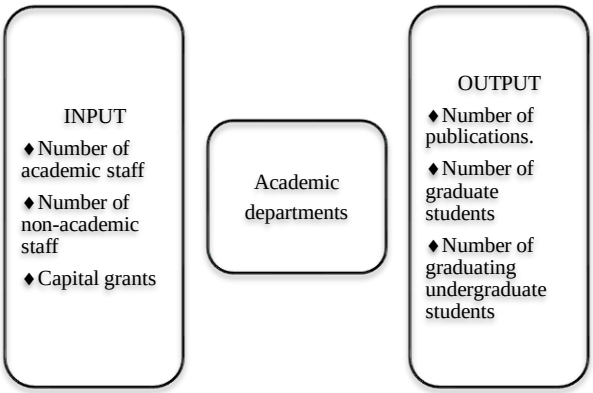

Figure 1. Input output variable and measurement

2. METHOD

This study has been conducted at academic departments in public university in Malaysia. The secondary data sources derived entirely based on the performance report of few offices which is Registration Office, Information Technology Office, Research Management Centre, University Publishing Information System, Centre for Academic Development and Training, Student Affairs Office and Academic Management Office respectively for the year 2016 until 2018. The first step in DEA is the determination of the DMU, which is the five academic departments in university. The next step is to identify the variables (input and output) and select a model. There are six variables for input and output, as shown in Figure 1, where the Cranes, Cooper, Rhodes model (CCR) is also applied, which aims to maximise the output with a set of inputs. Then the collected data was analysed using DEA-Solver-LV version 8 to obtain the results.

3. RESULTS AND DISCUSSIONS

This study uses data from the years 2016 to 2018. Two different aspects are taken into account when analysing the data. Firstly, the DEA's usual separate view, which looks at the performance of the departments in three different years. Secondly, the combined view, in which the performance of the departments in three years is considered as one. This study has opted for the first view only.

Table 1. Comparison of the efficiency score of the departments for three years (2016-2018)

Year	2016		2017		2018	
DMU	Score	Rank	Score	Rank	Score	Rank
A	0.993173	4	1	1	1	1
B	1	1	1	1	1	1
C	1	1	1	1	0.954946	5
D	0.869008	5	1	1	1	1
E	1	1	1	1	1	1
Mean	0.972436		1		0.990989	
SD	0.051782		0		0.018022	
Maximum	1		1		1	
Minimum	0.869008		1		0.954946	
Percentage of Efficiency (%)	97.2436%		100%		99.0989%	
Number of Efficient DMUs	3		5		4	
Number of Inefficient DMUs	2		0		1	

Table 1 clearly shows that the efficiency in terms of the performance of Divisions A and D increased dramatically from 2016 to 2018. In addition, the performance of inefficient Division C has gradually decreased from 2016 to 2018. The number of inefficient departments decreased from two inefficient departments in 2016 to one inefficient department in 2018. Furthermore, the efficient departments remained efficient over the years. The average efficiency was 0.972436, 1.0000 and 0.990989 in 2016, 2017 and 2018 respectively, which means that the performance of the departments was generally somewhat inconsistent over the three years. The departments that have maintained their efficiency from 2016 to 2018 are B and E.

Table 2. Inefficient departments for year 2018 only

		Input			Output			
DMU	Score	Number of academic staff	Number of admitted undergraduate students/ number of taught course students	Ratio student/ teacher	Number of publications	Number of graduate students	Graduates' employment rate	Total amount of research grants
C (2018)	0.94	0.00	6.89	2.39	0.00	0.00	5.41	0.00

Next comes a recommendation for improving the inefficient departments. Table 2 shows the inefficient departments for 2018, namely departments C. The inefficient inputs are the number of students admitted / number of students taught and the student / teacher ratio. The inefficient output is the employment rate of graduates.

The student/teacher ratio in Department C should be increased by increasing the number of academic staff, as the correlation between the student/teacher ratio and the number of academic staff is positive. Staff cannot simply be made redundant to increase efficiency as they are protected by labour law. Therefore, the only solution for the surplus academic staff is to transfer them to another department. However, Department C has to transfer the surplus academic staff, whereby it can assess the expertise of the academic staff and decide where they can be transferred to.

As for the output variables, Department C should increase the employment rate of its graduates to achieve efficiency. The department should put forward the names of its students to the industry. This will serve to increase the employment opportunities of the students.

4. CONCLUSION

In nutshell, the aim of this study is to determine the performance of academic departments using Data Envelopment Analysis (DEA). The inputs are the number of academic staff, the number of non-academic staff and capital grants. The outputs are the number of publications, the number of graduate students and the number of undergraduate graduates. The finding shows that departments B and E supersede other departments by maintaining their efficiency from 2016 to 2018.

CREDIT AUTHORSHIP CONTRIBUTION STATEMENT

Author1: Writing – original draft, Software, Methodology, Project administration. **Author2**: Conceptualization, Writing – review & editing, Validation, Supervision.

DECLARATION OF COMPETING INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

DATA AVAILABILITY

Data will be made available on request.

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