Evaluating the Efficiency of Faculties in University of Malaya Using Data Envelopment Analysis

S A M Ahmed¹, M A Talib¹, N F M Noor², R Jani³

¹Department of Applied Statistics, Faculty of Economics & Administration, University of Malaya, 50603 Kuala Lumpur, Malaysia
²Institute of Mathematical Sciences, Faculty of Science, University of Malaya, 50603 Kuala Lumpur, Malaysia
³Ungku Aziz Centre for Development Studies, Faculty of Economics & Administration, University of Malaya, 50603 Kuala Lumpur, Malaysia

saber@um.edu.my

Abstract. Public higher education sector worldwide is under a growing pressure to improve the quality and increase efficiency of its services. Limited financial resources as well as tight regulations and monitoring of the spending are characteristics of this public higher education sector. Another debated issue is the division of public money among the Higher Education Institutions (HEIs) in a country. University of Malaya is an example of a public higher education and it is considered as number one in Malaysia as HEI. UM in the latest QS Global World University Rankings 2021 has achieved the position 59th and the 9th in the regional Asia rankings. The main objective of this study is to provide the empirical evidence whether the efficiency of UM faculties is consistent with the international QS Global World University Rankings.

1. Introduction
Measuring the efficiency or performance of higher learning institutions can be an important economic tool in providing the benchmark to allocate appropriate fund for Higher Education Institutions (HEIs). Efficiency measurement can be performed to examine if the funds are utilized in the most optimized way as possible to improve the respective HEIs. In addition, the efficiency score measurement for each and every department or unit within the HEI could give further information on areas of improvement. It is important for any university to assess its faculty and determine which faculties are efficient/inefficient. This study applies Data Envelopment Analysis (DEA) to measure the relative technical efficiencies of the faculties, institutions, academies and centers in the University of Malaya. Based on the efficiency score of University of Malaya for 3 academic years 2012/2013, 2013/2014 and 2014/2015, the results are consistent with the QS Global World University Rankings. Therefore, this study is expected is to encourage Malaysian HEIs to improve efficiency of their specific faculties hence their QS ranking.

It is also important for University of Malaya (UM) to evaluate and assess its faculties to improve its continuous rank in the regional and international university rankings. The ranking of UM is regarded as an important issue because it indicates increasing or decreasing education quality inside its faculties, a standing on the economic resources and whether it is used in the optimal way, to improve the overall aspects inside UM such as students’ facilities and services, laboratories, building.
Measuring efficiency or performance is an important economic tool to provide an appropriate fund for the HEI and to optimize its usage, based on the efficiency score for each department or units within the HEI [6]. However, until this point of time, previous studies measuring the efficiency of specific faculties within a university are still untraceable. Many of the studies only look into the efficiency measurement of university as a whole which include UM. The latest study on measurement of the efficiency of public universities in Malaysia as a whole, with an application of Data Envelopment Analysis (DEA) was given by Talib, 2005[1]. According to this study, UM and University of Science, Malaysia (USM) are the top universities with 100% score of efficiency. Kuah and Wong, 2011 [7] measured relative efficiency for 16 Malaysian universities where they identified lacking exercises in these universities and suggested fitting activities to be taken for development. Since there are not many efficiency studies on Malaysian HEIs, the specific root of the inefficiency cannot be traced for potential continuous improvement efforts to be carried out. Therefore, measuring the efficiency or the performance of each specific faculty in a university is significant at this stage.

Our study embarks on the relative technical efficiencies’ measurement of the faculties, institutions, academies and centers inside UM entity, for the three consecutive academic years 2012/2013, 2013/2014 and 2014/2015. In addition, this could be the first study, which provides an empirical evidence if the findings are consistent with the QS Global World University Rankings. Hence the specific objectives of this study are firstly, to measure and scale the technical efficiency of UM faculties for the three specific academic years, secondly, to identify the most efficient faculty as the benchmark for the relatively efficient and inefficient faculties, thirdly to explore the key determinants of UM’s efficiency, fourthly, to compare the consistency of the empirical results obtained with the QS Global World University Rankings, and finally, to explore some important variables that help to improve efficiency for each faculty. With these specified objectives, recommendations to improve the efficiency of the corresponding faculties are proposed. The evaluation of performance based on each faculty would help to assess the efficiency of UM as a whole to further improve its rank in the QS Global World University Rankings.

2. Data envelopment analysis
Data Envelopment Analysis (DEA) is a non-parametric achievement appraisal strategy initially designed by Charnes, Cooper and Rhodes, 1978 [4] for measurement of relative efficiencies of organizations, institutions or decision-making units (DMUs). The DEA technique applies and uses the linear programming approaches to observe inputs burned-through and outputs created by Decision-Making Units (DMU) and builds an efficient production frontier as a conclusion in view of best practices and empirical techniques. DEA evaluates the efficiency of each DMU comparative with all the DMUs in the sample (organization, institution or any) including itself. This relative efficiency is calculated by obtaining the ratio of the weighted result of adding all outputs and the weighted result of adding all inputs. The weights are selected so as to achieve maximum optimality for each DMU. Therefore, the DEA methodology is concerned with technical efficiency. The study shows how DEA is used as an application in higher education institution and also, how DEA can be used as a measurement tool for social and economic performance. According to Banker et al [3], DEA is an increasingly popular methodology as a benchmarking approach for institutional planning, budgeting, and research. All of these will facilitate and will present a basic data envelopment model by the inputs and outputs variables which are chosen. Better chosen model will be impacted in more accurate analysis, because the outcomes DEA outcomes may give important data supporting HEI management. DEA does not simply empower the distinguishing proof of zones requiring improvement, yet additionally depicts the advancement prospects in those regions. Moreover, it permits decision-makers to concern to HEI weaknesses and strengths to increase the international and local ranking, the mode of fund allocation among HEI organizational departments, or the optimal size of these departments [11]. Also, there is one more important recommendation of DEA application in higher education settings, i.e., it can evaluate the efficiency of universities from different perspectives. McMillan and Datta, 1998 [8] used DEA to compare performance efficiency of the universities in Canada. Based on Nazarko and Saprauskas, 2014
[9], DEA is the most suitable for institutional educational. DEA models that require constant returns to the scale approach are called CCR models (the abbreviation allude to the main letters of the names of the technique's authors Charnes Cooper and Rhodes [4] or CRS (Constant Returns to Scale). The models used in variable returns to scale are called BCC (Banker, Charnes, Cooper) models, [2] or VRS (Variable Returns to Scale).

3. Methodology
In this study, DEA is applied in attempt to evaluate the technical efficiency of homogenous production units (referred as DMUs) and to measure the exact technical efficiency score (the ratio of the weighted sum of outputs to the weighted sum of inputs). In our case study, we will fix DMUs as the faculties of the UM. As stated before, DEA is the optimal method of mathematical programming. Its aim is to divide production units into efficient and inefficient production units. DEA can measure the efficiency of DMU with multiple inputs and multiple outputs. The inputs and outputs can be expressed in monetary and non-monetary forms i.e., our case here which is in the area of education where the number of academic staff, the number of non-academic staff or financial resources are taken as inputs and the number of students, the number of graduates or research quantum as outputs [5]. Setting clear reference points for UM faculties as HEI, comparative efficiency assessment may be treated as a substitute for market competition. All the faculties under study are, located in the same campus that the environmental variables are not taken into [9]. The following figure shows the DEA conceptual framework for UM Faculties:

![DEA Conceptual Framework](image)

**Figure 1.** DEA conceptual framework for UM Faculties

It is applicable to say that application of the DEA method does not require prior determination of weights. Optimization of weights is done for each object separately through solving linear programming task in order to maximize the relation of output/input as described in the Equation (1) by taking into consideration the constraints given. In this way, the strength of each unit is exposed:

\[
\text{Max } h_j = \frac{\sum_{r=1}^{s} u_{rj} y_{rj}}{\sum_{i=1}^{m} v_{ij} x_{ij}}
\]

subject to:

\[
\frac{\sum_{r=1}^{s} u_{rj} y_{rj}}{\sum_{i=1}^{m} v_{ij} x_{ij}} \leq 1, \quad j=1,2,\ldots,n;
\]

\[
u_{ij} \geq 0, \quad r=1,2,\ldots,s;
\]

\[
u_{ij} \geq 0, \quad i=1,2,\ldots,m.
\]
$y_{rj}$: The amount of the product $r$ generated by DMU$_j$ output
$x_{ij}$: the amount of the resource $i$ used by DMU$_j$ input
$u_{rj}$: weight of the output $y_{rj}$
$v_{ij}$: weight of the input $x_{ij}$

$n$ : number of DMUs
$s$ : number of the generated products;
$m$ : number of resources used;

Table 1 represents the selected variables in UM study case, with different notation $I$ for input variable and $O$ for output variable, which are computed using Algorithm 1. Based on the inputs/outputs variables listed in the table, this study will measure the technical efficiency for each faculty. Here both outputs and inputs are measured in physical terms, i.e., all inputs are only represented by one variable of interest in academic staff for each DMU (faculty), and outputs center the structure of students and their employment opportunity. This study also measures the average efficiency of the university as a whole, from the result obtained from each faculty. The type of data used here is secondary data and they are collected from the person in charge from each faculty in UM. The data collected belong to 12 faculties, 2 academies, 2 centers and 3 institutions, and do not include the foundation center because it is not considered as a higher education unit due to it only prepares the students to be on the standard level which is required for studying in UM e.g., English level or Mathematics level. Table 2 lists the variables considered in the UM case with one input and 3 outputs.

Table 1. Input Variables and Output Variables for the DEA Model of UM.

| Variable | Symbol  |
|----------|---------|
| The input: Academic Staff Number | AS |
| The output 1: Local Student Number | LS |
| The output 2: International Student Number | IS |
| The output 3: Employment Student Number | ESN |

Table 2. List of variables in UM study case

| Input Variables | $I_1$ | Number of academic staff. (AS) |
|-----------------|-------|-------------------------------|
| Output Variables | $O_1$ | The total number of local graduates (undergraduate & postgraduate) from each faculty (LG). |
| | $O_2$ | The total number of graduate International students (undergraduate & postgraduate) (IG). |
| | $O_3$ | The total number of the students who are employed 6 months after graduation (ESN). |

4. Dea empirical results
In this study, as it is assumed that each faculty, institution, academy and center in UM are all homogeneous. The efficiency scores generated by solver are arranged in 3 sets, according to the three academic sessions and each set in the table has efficiency scores for each DMU. The solver results
generated contain 3 sets of figures, i.e., the first set is the efficiency scores of each DMU, and the second set is the variables (the input and output), and the last set is the benchmarks or peer referents for each DMU. The results produced by the DEA model are measured by the relative efficiency for each target of DMUs, and this relative efficiency is measured with reference to the considered set of the universities in comparison with the rest of the other DMU. Each faculty, center, academy or institution is considered in turn to select its most favorable weights. The efficiencies of all other DMUs of UM are computed by using these sets of weights.

Algorithm 1: Calculate DEA Based on CCR-CRS output-oriented model and by using Linear Programming Solver

1) Input \( I_i = I_1 \), Number of academic staff. (AS) 
\( O_j = O_1 \) (Local Student Number LS), 
\( O_2 \) (International Student Number IS) 
\( O_3 \) (Employment Student Number ESN) 
2) Key in the Maximize function in Equation (1) 
3) Key in Constrains in Equations (2)-(4) 
4) Define the dimension for each variable 
5) Run and get the result for each DMU

5. Summary of results and findings
In this section we summarize DMUs of UM, where DEA results can be used to assist in setting of target values for input and output. Through analysis, evaluation on how many inputs must be decreased or output to be increased in order for each DMU to become more efficient can be conducted. By identifying the nature of returns to scale, the results can indicate if a firm has to decrease or increase its scale (or size) in order to minimize the average cost. This would allow the decision makers to be aware of the required resources for each DMU and to put more control on the budget and financial situation for the respective university by identifying a set of benchmarks. Based on that achieved full efficiency score of 100%, other DMUs’ can improve their own practices to improve the efficiency score towards the benchmarks. According to Figure 2, four of the DMUs keep their full efficiency of 100% for the 3 academic years considered and these units are, Faculty of Business & Accountancy (FBA; DMU4), Faculty of Engineering (FEN; DMU10), Faculty of Law (FL; DMU12), Asia-Europe Institute (AEI; DMU15) and International Institute of Public Policy Management (INPUMA; DMU17). These four DMUs should be taken as referent peers for all other UM faculties. Based on this result, the decision makers can share their valuable experience so that other UM units can rise from their level of performance. In general, all other DMUs require some works for their improvement. For instance, Faculty of Built Environment (FBE; DMU5) has not reached to full efficiency level or perfect performance. This faculty may need few years but in overall, it is doing well in improvements. Some cases need more studies because the efficiency score of a year may increase then decrease in the next year just like for the case of Faculty of Economic & Administration (FEA; DMU8). By magnifying the last three bars in Figure 2, Figure 3 which represents the average efficiency of UM Table 3 through the three consecutive academic years is obtained.
The data in Figure 3 can be represented by the following table.

Table 3. Average Efficiency of UM for three academic years (2014 to 2016)

| Average Efficiency of UM from year 2014 to 2016 |        |
|-----------------------------------------------|--------|
| Eff 2014                                      | 77.55% |
| Eff 2015                                      | 80.33% |
| Eff 2016                                      | 81.34% |

6. Overall average of UM

Both table and bar chart indicate that there is a steady improvement of the overall efficiency in UM with full efficiency is expected within the next few years, although concern must be given to the faculties with inefficiency scores.

In the first academic year 2012/2013 of our study, the overall average efficiency score is 77.55%, and it is increased by 2.78% to be 80.77% in the next academic year 2013/2014 while in the last academic year 2014/2015, the efficiency score has kept going up to be 81.34%. The increasing trend of efficiency score of overall DMUs in our study is consistent with the gradual increase of UM’s
performance (Table 4) as listed in the QS Global World University Rankings. The QS Global World University Rankings uses an interactive ranking table to explore the world’s top universities, with options to sort the results by country, region and subject area [10].

Table 4. UM based on the QS Global World University Rankings for the three academic years

| Academic Year | Ranking Year | QS World Ranking | Asian Ranking |
|---------------|--------------|------------------|---------------|
| 2012-2013     | 2013-2014    | 167              | 33            |
| 2013-2014     | 2014-2015    | 151              | 32            |
| 2014-2015     | 2015-2016    | 146              | 29            |

Table 4 shows that the UM world ranking in the year 2013/2014 was at 167th and in Asian ranking was at 33rd. In the following academic year, the university jumped 16 positions to 151th in the world ranking and improves one place in Asian ranking to 32nd. For the academic year 2014/2015, UM’s world ranking is at 146 and it climbed by 3 places in Asian ranking. Our results actually support both world ranking and Asian ranking in the context of University of Malaya.

7. Conclusion

There are four major contributions derived from this study in relation to the efficiency of faculties of University of Malaya. They are listed down as follows:

- A set of the most important indicators according the QS Global World University Rankings that is used to find the technical efficiency for DMUs’ UM (output and inputs) is introduced.
- Measuring the relative technical efficiency of each unit inside UM introduces knowledge for the management control and also, research on the performance of the University of Malaya in the three consecutive academic years.
- The potential areas for improvement, in particular, the potential savings in the operating cost for the inefficient DMUs’ UM have been explored.
- Two policy implications have been identified with regards to the need for a centralized system to enable the faculties and the UM as a whole to compile a complete and reliable set of data, and the need for performance-based funding allocation for more further improvement efficiency score for each DMU inside UM.
- Based on Figure 2 with full efficiency score 100% are for the 3 academic years of the study and these units are, Faculty of Business & Accountancy (FBA; DMU4), Faculty of Engineering (FEN; DMU10), Faculty of Law (FL; DMU12), Asia-Europe Institute (AEI; DMU15) and International Institute of Public Policy Management (INPUMA; DMU17).
- According to QS Global World University Rankings by Subject 2020, five DMUs (Faculty of Business & Accountancy, Faculty of Engineering, Faculty of Law, Asia-Europe Institute and International Institute of Public Policy Management) with full efficiency scores of 100% are also ranked at 1st position as top faculties in their subjects.
- Meanwhile, faculties with a decay or a hesitate efficiency score needs to improve its performance and efficiency score based on critical decisions by university council or decision-makers. These decisions could be, decreasing the number of students in the faculty, increasing the number of staff or maximizing the allocated budget for each low DUM efficiency score.

References

[1] Abdul Talib M 2005 Measuring the efficiency of public universities in Malaysia: an application of data envelopment analysis (Doctoral dissertation, Universiti Malaya).

[2] Banker R D, Charnes A and Cooper W W 1984 Some models for estimating technical and scale inefficiencies in data envelopment analysis Management science 30 (9) pp 1078-1092
[3] Banker R, Emrouznejad A, Bal H, Alp I and Cengiz M A 2013 June. Data Envelopment Analysis and Performance Measurement Proceedings of the 11th International Conference of DEA

[4] Charnes A, Cooper W W and Rhodes E 1978 Measuring the efficiency of decision making units European journal of operational research 2 (6) pp 429-444

[5] Cunha F G P, Rocha F F D and Lorand-Metze I G H 2012 The utility of multiparametric flow cytometry for the detection of minimal residual disease in acute lymphoblastic leukemia Revista brasileira de hematologia e hemoterapia 34 (5) pp 396-396

[6] Hirao Y 2012 Efficiency of the top 50 business schools in the United States Applied Economics Letters 19 (1) pp 73-78

[7] Kuah C T and Wong K Y 2011 Efficiency assessment of universities through data envelopment analysis Procedia computer science 3 pp 499-506

[8] McMillan M L and Datta D 1998 The relative efficiencies of Canadian universities: a DEA perspective Canadian Public Policy/Analyse de Politiques pp 485-511

[9] Nazarko J and Šaparauskas J 2014 Application of DEA method in efficiency evaluation of public higher education institutions Technological and Economic development of Economy 20 (1) pp 25-44

[10] QS Top Universities. (n.d.). Retrieved February 10, 2021, from http://www.topuniversities

[11] Talat Ş 2016 PONTE International Scientific Researches Journal, Florence, Italy Data Envelopment Analysis with Missing Data: An Expectation Maximization Approach 72 (3)