MEASURING THE RESEARCH EFFICIENCY OF UNIVERSITI TEKNOLOGI MARA (UITM) BY USING DATA ENVELOPMENT ANALYSIS (DEA): A CASE STUDY IN UITM PERLIS

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Abstract:

This paper aims to measure research efficiency of UiTM Perlis by using two different models, which are the Charnes, Cooper, and Rhodes (CCR) model and the Banker, Charnes, and Cooper (BCC) model. The data used is secondary data started from 2018 to 2022, obtained from the departments involved such as the Academic Affairs Division (HEA); Industry, Community, and Alumni Network (ICAN) Office, and Administration Office, UiTM Perlis. It has also been distinguished the competencies for each year and examined the current trends towards 2025, with the aim of achieving the mission of the UiTM2025 strategic plan. There are five decision making units (DMU's) for both aspects studied; 2018, 2019, 2020, 2021, and 2022, which are the five distinguished years for this study. The use of the two models in this study, namely CCR-I and BCC-I is to ensure that the ranking analysis results are more accurate and precise. Both models use input-oriented model functions as a way of maximizing efficiency in order to increase the number of fairies. For research efficiency, two DMU's which is 2018 and 2020, were ranked first for both models. Thus, making this DMU's ranked first for both models.

Introduction

Although UiTM is a public university that has less autonomy compared to other private universities, this is not an excuse for an educational institution to waste the public funds channelled. Thus, it is crucial to measure the efficiency of the university to help UiTM solve problems that may arise. There are various methods to measure the performance of an organisation. Ghasemi et al. (2020) has outlined several methods including the Stochastic Frontier Analysis (SFA), Fuzzy Least Square Support Vector Machine (FLSSVM), and Data Envelopment Analysis (DEA). Of these, DEA is among the best methods and has become a basis to assess the efficiency of a parameter. This is in line with Rosenmayer (2014), who stated that DEA is one of the most appropriate methods to compare the efficiency between units that provide public services, besides being a popular performance measurement method for non-profit institutions such as schools, hospitals, and universities due to its ability to control multiple inputs and outputs without any prior assumptions on the monetary values of the inputs and outputs (Tse & Yew, 2011). Yet, due to lack of data and lack of awareness, there is still no detailed research paper related to the research efficiency of the faculties in UiTM; instead, UiTM has only focused on the QS Rankings and THE Rankings as annual benchmarks. This causes possible bias, as the level of ranking is neither holistic nor detailed enough to improve the capabilities of UiTM itself. Therefore, this study is crucial and acts as a steppingstone for researchers to explore the weaknesses of the organisation that can be improved in the foreseeable future, as well as help UiTM achieve the main target of UiTM2025, which is to become a Globally Renowned University. Referring to the UiTM2025 strategic plan which outlines 23 key strategies, 144 key initiatives, 22 key performance indicators, 129 performance indicators, and finally the aspiration for the university to achieve the strategic goal of becoming a Globally Renowned University in 2025 (Taufek, 2020), this HEI must be on the right track to align and fulfil all aspects that will be measured in the plan. The aspect of quality, as usual, is the main point that needs to be evaluated. This is important to emphasize in addition to the aspect of satisfaction measured in all parameters, for example, student enrolment, production of indexed studies, marketability of graduates, and so on. This matter needs to be emphasised to ensure that the quality of performance of academic and non-academic staff, undergraduates, and postgraduate students as well as UiTM graduates themselves reaches the set level. Cooperation from all parties, including all management committees in all campuses, is also the starting point for the main mission to achieve the strategic goal. The reality today, however, is that UiTM has more than 30 campuses, 17 faculties, and two colleges of study throughout Malaysia, offering 155 bachelor's degree programs and 72 diploma and certificate programs, which makes it difficult for this HEI to determine the level of efficiency for all parameters. In addition, due to lack of awareness, there is no detailed research paper related to the faculties at UiTM as this HEI only makes the QS Ranking and the THE Ranking among others as the benchmark of the current level of competency. As a result, UiTM will encounter problems in making the university an international university by 2025. In addition, this level of efficiency also ensures that UiTM is able to regulate public funds provided annually through the presentation of the annual budget of the Malaysian government. In the presentation of the federal government budget in 2021, the government has outlined several steps under the Fourth

Strategy: Prioritising the Inclusion Agenda. Among them was 'Step 1: Bumiputera Empowerment' where the government has promised to continue efforts to support Bumiputera development to reduce racial inequality. For 2021, a total of RM11.1 billion was provided, which was an additional RM3.1 billion compared to the previous year (2020 = RM8 billion). There was also an increase in 2022, where a total of RM11.4 billion was provided to implement various initiatives under the Bumiputera development sector. Of that, a total of RM6.5 billion (2021) was allocated to provide access to quality education to Bumiputera institutions such as MARA and UiTM, to run specific programs including the digitisation of TVET learning and upgrading certificate-level programs to diplomas. This increased in the following year (2022), where a total of RM6.6 billion was provided for educational facilities for Bumiputera children among others under the initiatives of MARA, UiTM, and Yayasan Peneraju (Kementerian Kewangan, 2021). These public funds must be used properly, therefore, the measurement of the efficiency level of this university must be carried out in detail and publicised to prove that UiTM is one of the best universities not only at the national level, but internationally. In response to this problem, a basic empirical study will be conducted on one of the UiTM branch campuses, namely UiTM Perlis Branch, Arau Campus, which has seven main faculties. This study will use DEA as a tool to cover the current level of performance of the faculties in UiTM Perlis. This matter is also chronicled by the reality that UiTM Perlis is one of the oldest campuses in Malaysia, and thus needs to be scrutinised carefully so that UiTM Perlis has no difficulties in complying with the items contained in the UiTM2025 strategic plan.

Literature Review
Ghasemi et al.(2020) stated that the university is an important medium in advancing the development of the country through efficient training, efficient human resources, and skills to meet the needs of society in various fields. This is because the university produces a professional workforce every year and it is the backbone of the industry players in a country (Fu & Fong, 2022). The higher education system is still regarded as one of the key drivers that contribute to different aspects of socioeconomic development. Most developed economies exhibit a close relationship between the importance of an HEI and economic development (Shamohammadi & Oh, 2019). UiTM is also not left behind in ensuring that the current level of performance of this sacred institution remains excellent.

Developing countries around the world aim to improve their educational institutions to encourage positive national growth. This is because they believe that education is the foundation of a civilization's economic stability. For example, Alabdulmenem (2017) in Saudi Arabia, Shamohammadi & Oh (2019) in Korea, Mammadov & Aypay (2020) in Turkey, Ghasemi et al. (2020) in Iran, Ma et al. (2021) in China, and Fu & Fong (2022) in Taiwan all found a significant increase in funds invested by their countries respectively. The funds invested are in the field of research and development (R&D) to create new products in the country that can be emulated by other countries. In addition, this investment is also influenced by the university ranking chart issued each year such as QS Ranking, THE Ranking and so on. Studies on an institution's efficiency and performance have long been conducted around the world to assist stakeholders make decisions that will ideally improve the institution's performance directly or indirectly in the future, where measuring university efficiency and productivity provides an indirect analysis of public funding management. This helps policymakers make better decisions and enhances university productivity, as a consequence, public funding management will be better (Rosenmayer, 2014). This is in line with the study from Chen et al. (2021) which underlined that the state of Tennessee in the United States has

been evaluating HEI performance since 1978. Performance evaluation is now used in two-thirds of the United States. In 1985, the Department for British Education and Science published a study which stated that good management should be based not just on the efficient use of resources but also on the efficacy of the outcomes.

There was also a requirement to develop and implement performance measurement techniques (Chen et al., 2021). Such a responsibility enlarges the demand for colleges, universities, and other higher education institutions to provide high quality educational programs and employ efficient governance systems. While the quality of educational programs may be measured against industry and professional standards, the efficiency of college or university governance systems may be assessed through their use of available financial, human, and other resources to generate academic-related work outputs such as: number of graduates, number of research publications, and academic performance of students, among others (Alabdulmenem, 2017). An institution has a responsibility to find the best option to optimise the utilisation of inputs and create the highest potential output (Ghasemi et al., 2020). This is supported by Chen et al. (2021) who stated that any organisation, including HEIs, must run efficiently to remain competitive and be a top HEI and the choice of the global community.

Rosenmayer (2014) said that efficiency expenditure programs are evaluated in the case of public spending programs using the so-called 3E module, which explains the three Es (Economy, Efficiency, and Effectiveness) as follows:

(1) The first part of the three Es model is economy, which covers the financial aspects of the work being done. The cost of the resources spent, and the value of the output delivered are used to measure the economy.
(2) Efficiency can be evaluated in terms of the inputs and outputs required. It has to do with how the work is accomplished. For example, efficiency improves when the same job can be finished with fewer inputs or resources, and vice versa.
(3) Effectiveness can be defined in terms of the results obtained. It narrows down to whether the goals are met. Effective performance requires completing the work properly that is determined by establishing specific objectives before beginning work and then assessing whether the objectives were met.

DEA has been used to assess relative efficiency between institutions as well as between university departments or courses. Due to its ability to handle many inputs and outputs without making prior assumptions on the monetary values of the inputs and outputs, DEA has become a common performance measuring tool for non-profit institutions such as schools, hospitals, and universities (Tse & Yew, 2011).

A variety of methods have been used to evaluate the performance of universities, while the most common methods are SFA, FLSSVM, DEA and others. However, Tse & Yew (2011) emphasised that SFA is good in handling data with a certain level of uncertainty; however, it is not easy to be applied for multiple inputs and outputs. Ghasemi et al. (2020) stated that it is not necessary to give a mathematical form for the production function in DEA. Furthermore, DEA can handle many inputs and outputs, and the sources of inefficiency for each evaluated unit may be analysed and quantified.

In university efficiency assessments, there is no definitive criteria to guide the selection of inputs and outputs (Tse & Yew, 2011). Various types of inputs and outputs have been selected by the researcher in previous research, driven primarily by the need of the institution itself to get results that will benefit the institution. This is also supported by Rosenmayer (2014) who stated that DEA is able to use more parameters of input and output to evaluate which units under examination are the most effective, and to compare other units with it. Tse & Yew (2011) divided the field of performance study into two categories: research efficiency and teaching efficiency in Asian universities. At the end of the study, they focused on identifying universities that perform well in the field of research, similar to Ma et al. (2021), or, in the field of teaching, both at the same time. The method was also used by Chen et al. (2021) who divided the selection of inputs and outputs into two different parts, which is research and teaching. They measured the level of performance of 58 universities in China by differentiating the region of university located (eastern, central, and western of China). Also, Shamohammadi & Oh (2019) in a study that measured the change in efficiency of private universities in Korea also used a method of comparison between research and teaching fields. The study was conducted on 57 private universities in South Korea.

This differed to the study by Ghasemi et al. (2020) who applied several models to test a variety of inputs and outputs which separated into seven subunits, which are presidency unit, education vice-presidency department, academic department, research department, finance and administration vice-presidency department, finance department and human resources department. The goal of their project was to develop appropriate models to estimate the efficiency of hierarchical structures using DEA and to apply these models to compare the efficiencies of Farhangian University's campuses in Iran. The results show that certain campuses have great efficiency while others do not, implying that these campuses do not optimally utilise their inputs and outputs.

This proves that other countries have conducted relevant studies in depth to ensure their institutions are on the right track. This is important because efficiency is defined in such a way that the technical efficiency should be maximised for production of such goods; an allocation of which does not reflect current conditions of demand (Rosenmayer, 2014). It also proves that universities are important components of the economy and produce both human capital and new knowledge (Ghasemi et al., 2020).

Methodology

DEA offers policymakers important information to help improve DMU performance. This study attempts to compute the efficiency for UiTM Perlis by utilizing the model given in this study as well as those found in the DEA model. It also attempts to differentiate between the efficiencies for each year and examine current trends towards the year 2025, with the goal of achieving the UiTM2025 strategic plan. For each year which each includes data for the previous five years, i.e., from 2018 to 2022 the model described in this study will be compared to the fundamental CCR and BCC model. These data have been collected, verified, validated, and analyzed through the use of Microsoft Office Excel Solver.

In addition, the argument in the research efficiency is that universities employ research staff, secure research grants (fund), and enrol research students to produce the output, which is the number of publications. Some studies considered research grants as an output based on the argument that they are the outcomes of research performance (Tse & Yew, 2011). This means

that if the research performance of a university is better, more funds will be attracted. In contrast, in this study, research grants are treated as a resource for research activities, thus they are considered as an input. The input and output for research efficiency is shown in Table 1.

Table 1: Definition Of Inputs And Output For Research Efficiency

Input	Definition	Output	Definition
X1: Number of academic staff.	Total number of full-time lecturers.	Y1: Number of publications	Total annual publication counts for UiTM Perlis, published in World of Science (WOS) and Science Direct journal.
X2: Amount of research grants (fund).	Total amount of annual research funds		
X3: Number of postgraduate students	Total number of master and PhD students.		

CCR-I Model

The CCR input-oriented DEA model, which has a constant return to scale, was used to test the institution's inputs and output. The input-oriented model is focused on increasing DMU efficiency. CR is an important Constant Return to Scale (CRS) approach based on the mathematical model in the DEA literature. This model measures the max ratio of weighted output to input. The ratio of every DMU should be equal to or less than 1 expressed as constraints (Charnes et al., 1978). Ghimire et al. (2021) suggested that if the ratio of weighted output to input is 1, then the DMU is considered efficient. Otherwise, it is inefficient. The weighted sum formula could be used to obtain the efficiency scores of each DMU. To maximize the efficiency value of the analysed DMU's and determine technical efficiency, the nonlinear weighted sum formula is applied. The weighted sum is used to compute the aggregate of input and output by dividing the greatest ratio of total weighted outputs by the total of weighted inputs, with corresponding ratios for each DMU being less than or equal to one.

BCC-I Model

To make the analysis more plausible, the BCC-I of the DEA model is utilised to analyse the institutions' input and output data. It should be noted that the CCR is input-minimizing and output-maximizing. Formulations provide comparable outcomes, which the BCC model seems to be incapable of providing such outcomes. As a result, in the input-oriented BCC model, the formulation minimizes the outputs given the inputs and vice versa.

Result and Analysis

In this study, DMU's represents five years of study, namely 2018, 2019, 2020, 2021 and 2022, where each DMU's has three inputs and one output in order to measure the efficiency of research efficiency in UiTM Perlis. The three inputs are the number of academic staff, number of postgraduate students and amount of research grant, and the output is the number of publications. Table 2 represents the efficiency score of the research efficiency for the CCR-I and BCC-I models.

According to the Ji et al. (2015), they found that the BCC-I model has a higher accuracy than the CCR-I models. This is because the BCC-I model has been improved from the CCR-I model to ensure that the analysis performed on a study is more accurate by adding additional constant

variables to the original formula, which is the CCR-I model in this case (Pai et al., 2020). It is clearly shown when four DMU's for the BCC-I model recorded full efficiency compared to the CCR-I model, it only resulted in two DMU's recorded full efficiency.

It can be concluded numerous of inputs in research efficiency is not efficient in the CCR-I model but is productive in the BCC-I model. It is only in the year 2020, where it maintains its position among all other DMU's that are inefficient on the CCR-I and BCC-I models. This shows that in this year 2020, the three inputs listed are not used well to produce the appropriate output. In addition, this analysis also shows that only 2018 and 2021 recorded full efficiency for both CCR-I and BCC-I models, proving that these two DMU's are the best years for research efficiency.

Table 2: Efficiency Score for Research Efficiency

DMU	CCR-I Model	BCC-I Model
2018	1.0000	1.0000
2019	0.5847	1.0000
2020	0.8635	0.9759
2021	1.0000	1.0000
2022	0.9556	1.0000

Keep in mind that only inputs or outputs with a score of 100% or 1 are considered fully efficient. Moreover, the table shows the performance of research efficiency for UiTM Perlis for the CCR-I model. According to the Table 2, there are 3 DMU's that score between 0.9 and 1.0, but only two of them are efficient: that is in 2021 and 2018. While in the year of 2022, the DMU's have approached full efficiency. In addition, for the remaining DMU's in 2019 and 2020, both scored less than 0.9 and exceeded 0.5. However, efficiency score for the BCC-I model is also illustrated in Table 2. It also shows a significant improvement in efficiency scores from the previous model, the CCR-I models. The graph clearly shows that 4 DMU's have reached 100% efficiency and only 1 DMU's has reached a scale above 0.9 which is in the year of 2020.

Conclusion and Recommendations

This study combined the correlation of the number of publications for each year directly with the relationship of three input components: the number of academic staff, the number of postgraduate students, and the amount of research obtained. Not only that, but this study also recommends the best value to be replaced with the original data for each input and output to ensure that each DMU meets the efficiency level. The data shows that UiTM Perlis is on the right track and shows a very good and efficient achievement for the five years tested, for item research efficiency. This paper also discovered that, the analysis of research efficiency for the year 2018 and 2021, in which all inputs are fully used to produce output at the maximum efficiency level with a score of 1 or 100%. Both models have been tested, namely the CCR-I and the BCC-I model, and the results of the test showed that its position has not changed and is ranked first. This means, in the year 2018 and 2021, it can be mentioned as the two greatest DMU for the aspect of research efficiency. Meanwhile, the study proves that the development research component is at a very efficient for all the DMU's involved, where the efficiency score obtained for the 5 DMU's according to the BCC-I model is above 0.95 or 95%, and it shows that UiTM is at an efficient level. Indeed, UiTM Perlis need to maintain this achievement to ensure UiTM's 2025 strategic plan succeeds in achieving efficiency performance in this

research. Indeed, the results of this study can be used as additional references to stakeholders to ensure that UiTM Perlis is on the right track to achieve the UiTM2025 strategic plan, which is towards the Global Renowned University 2025.

For the future studies, it is suggested that researchers consider more inputs and outputs to ensure that the analysis obtained is more varied, because DEA is more sensitive and provides a more accurate analysis if there are variations in the data. In addition, future researchers are also suggested separating the DMU's into faculties or departments, or more precisely, if the DMU's discuss something deeper and not just on the surface; focusing on the subject of substance over form.

Acknowledgements

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