MEASURING THE EFFECTIVENESS OF UNDERGRADUATE PROGRAMS BY A NONPARAMETRIC METHOD

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ABSTRACT. Measuring the effectiveness of programs is not an easy task since the related variables may be affected by environmental factors which are often not under the control of the policy maker. Besides that, the use of output(s) alone without considering the input(s) to measure the effectiveness of programs may depict a wrong picture about the programs. If the ratio of output(s) to input(s) is defined as the basic measure of efficiency, effectiveness relates the input or output to the final objective(s) to be achieved, that is the outcome(s). The aim of this paper is to propose a model to estimate effectiveness of undergraduate programs by using a nonparametric method, known as Data Envelopment Analysis (DEA). In the tertiary educational setting, if the graduates are defined as the output, then it is argued that the employed graduates could be considered as the outcome, whereas the main inputs are the academic staff. As the academic staff are of different rank with different contribution, this feature should be reflected in any performance measure of academic institutions. The effectiveness model for undergraduate programs is proposed as the ratio of the number of employed graduates six months after graduation to numbers of academic staff at five different rankings. This model was used to analyze the effectiveness of 26 selected undergraduate programs in a university. The results show that only 10 were effective, and 16 were not effective for year 2009. Besides the results analyzed by the proposed model, the effectiveness measure based on a ratio of one outcome to one input, that is without considering the superiority of the inputs is also included for comparative analysis. As expected the two results are different. The result based on the proposed method is suggested to be used for further analysis and improvement action. Besides that, the proposed model may be used in different context with certain adjustment especially in the selection of input and outcome.

Keywords: data envelopment analysis, effectiveness, outcome, input, undergraduate program

INTRODUCTION

Education has been always a main agenda to every nation at any point of time. In ensuring the educational process has fulfilled the objective of educational program, some kind of evaluation mechanism has to be used by the educational authority to measure the performance of the program. It is even more important if the programs are offered by public institutions which depend mostly on public expenditures. The public institutions must be accountable and assure that the public resources are used in the most efficient and effective way.

The higher education includes post-secondary, diplomas, degrees, and post-degrees programs. Issues in higher education regarding graduate performance, staff performance and institution performance had often been studied. For example, Ruzanita & Razak (2002) study on measuring the relative efficiency of schools in a Malaysia university, while Thanassoulis, Kortelainen, Johnes & Johnes (2010) measure the cost and efficiency of higher education institutions in England. In addition, Al-Bagoury (2013) evaluates the efficiency of African higher education systems of fifteen countries, and Nazarko & Jones (2014) estimate the comparative efficiency of nineteen Polish universities of technology. Efficiency can be defined simply as 'doing the thing right', while effectiveness is 'doing the right thing right'.

The aim of this paper is to propose a model to measure effectiveness of undergraduate programs that utilizes the non-parametric technique known as Data Envelopment Analysis (DEA) (Charnes, Cooper & Rhodes, 1978, 1981). A conceptual framework that relates efficiency and effectiveness is also discussed prior to the proposed model. Furthermore, the feasibility of the model is shown in estimating the effectiveness of 26 undergraduate programs for year 2009 of a public university in Malaysia. This paper consists of five sections. The following two sections discuss the efficiency and effectiveness concepts, and the DEA. The last two sections are related to results with discussion and the conclusion.

CONCEPTS OF EFFICIENCY AND EFFECTIVENESS OF PUBLIC PERFORMANCE

Public performance measurement is a compilation of report about efficiency, quality and effectiveness of programs. These measures are important for the public sector to improve its performance especially in terms of the provision of the services. According to Mwita (2000), performance measurement is the individual or group final output to achieve stated goal and objectives. Goal and objectives can be achieved when institutions utilize their limited resources to fulfill the stated objectives (Mancebon & Molinero, 2000).

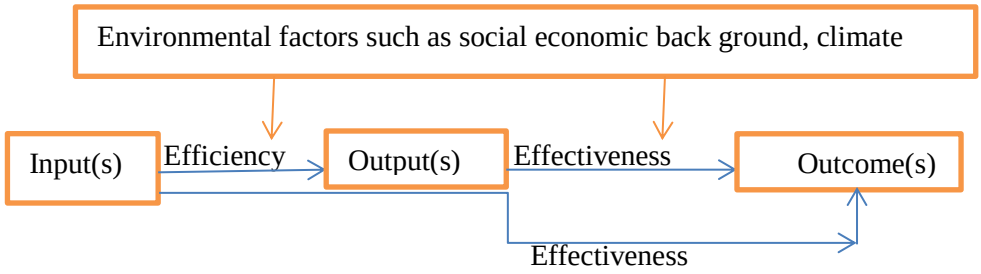

Figure 1. Conceptual Framework of Efficiency and Effectiveness

The relationships between inputs, outputs and outcomes have become the basis for the analysis of efficiency and effectiveness. Farrell (1957) has already investigated the question how to measure efficiency and he defines efficiency as a ratio of output(s) to input(s). Since that time, techniques to measure efficiency have improved and investigations of efficiency have become more frequent in both private and public sectors. Nevertheless, the measurement of efficiency and effectiveness of public institutions remains a conceptual challenge. Problems arise because public spending has multiple objectives and because public sector outputs are often not sold on the market which implies that price data is not available and that the output cannot be quantified.

The conceptual framework of efficiency and effectiveness as illustrated in Figure 1 is suggested by (Mandl, Dierx & Ilzkovitz, 2008), which makes the link between input, output and outcome. Effectiveness relates the input or the output to the final objectives to be achieved, that is the outcome. The outcome is often linked to welfare or growth objectives and therefore may be influenced by multiple factors including the environmental factors which may or may not be within the control of the policy maker. For instance, if the efficiency of educational spending is analyzed closely, the wage structure may be seen as an external factor, whereas if the efficiency of public sector is investigated as a whole, the wage structure might be an important input.

Furthermore, the distinction between output and outcome is often blurred. Output and outcome are used in an interchangeable manner, even if the importance of the distinction between both concepts is recognized. Therefore, the efficiency or effectiveness in any context, specifically in a higher educational institution context is complex and often controversial task. Applying efficiency or effectiveness to university performance measurement will inevitably involve the use of surrogate measures Wilkinson (1991). Therefore, a clear understanding of the conceptual difference in assessing either university processes, outputs or outcomes is important.

Inputs

Assessing the efficiency and effectiveness of public spending requires the measurement of the inputs entering into the production of public sector activities. This can be done in monetary and non-monetary (physical) terms. Inputs are resources that influence the output or result obtained (Thanassoulis & Dunstan, (1994). In the higher educational institutions, academic staff are the backbone of a university and the ranking of universities are often evaluated based on the number of professors that the universities have. So, since the undergraduate programs are the subjects to be evaluated, this paper suggests lecturers from different levels of superiority as the inputs. Five types of academic positions are considered namely, professors, associated professors, senior lecturers, lecturers and tutors. A professor is the highest position which an academic staff can achieved, followed by associate professor, senior lecturer and tutor, where the last position is often regarded as a temporary position.

Outputs

The public sector, however, mostly provides non-market goods and services, which implies that their market value is usually unknown. Output is the aim of the public sector to produce and the output of the public sector has to be defined. An option is to use a volume measure of outputs that allows efficiency or effectiveness to increase and decrease over time. In the context of universities, or specifically the undergraduate programs, number of graduates or the degree attainments could be defined as the output.

Outcomes

The outcome has to be seen in a broader context, which covers all the good long-term impacts of public programs and should capture the various dimensions of society values. Such achievements reflect the effectiveness of different kinds of programs or policy measures. It is difficult to disentangle the effects of different outputs on the outcome. Outcome is, moreover, often determined by external factors, such as life style and socio-economic backgrounds. It is therefore very difficult to isolate one transmission channel from another (Mandl, Dierx & Ilzkovitz, 2008). In the context of undergraduate programs, number of employed graduates could be defined as the short term outcome, while the graduates' performance in their working atmosphere may be defined as the long term outcome which is quite difficult to trace. This paper defines the outcome of undergraduate programs as the number of graduates who were employed six months after their graduation.

DATA ENVELOPMENT ANALYSIS

DEA is a linear programming model is developed by Charnes et al. (1978) to produce relative efficiency of each subject or decision making units (DMUs) under investigation. DEA is also a productivity measurement technique that measures the relative efficiency of public sector organizations which produce multiple outputs from multiple inputs in order to measure their performances. Efficiency measurement was found by Farrell (1957) but it only focuses on the ratio of single output to single input. This is the drawback of the model because organizations deal with multiple inputs and multiple outputs. Charnes et al. (1978) unfolds the model that has been found but with a different approach that deals with multiple inputs and outputs. This model is more practical because in reality the organization uses multiple inputs to produce multiple outputs. There are many DEA models that can be used to measure the efficiency such as Banker-Charnes-Cooper (BCC) model, Additive Model, Charnes-Cooper-Rhodes (CCR) but this study focuses on model developed by Charnes et al. (1978) known as CCR model.

The proposed model

Instead of considering an efficiency model, this paper proposes a model to estimate the effectiveness of 26 undergraduate programs in 2009 with five (5) inputs and one (1) outcome, and the effectiveness of each program needs to be optimized one by one. The proposed model is as follows.

$$\text{Maximize } K_e = \frac{W_1 Y_{1e}}{\sum_{i=1}^{5} V_i X_{ie}}, \qquad e = 1, 2 \ldots, 26 \tag{1}$$

Subject to

$$\frac{W_1 Y_{1m}}{\sum_{i=1}^{5} V_i X_{im}} \leq 1, \qquad m = 1, 2 \ldots, 26$$

$$W_1 \geq 0, V_1 \geq 0, \quad i = 1, 2, 3, 4, 5$$

where
K_e = effectiveness score of program e
Y_{1e} = number (no.) of employed graduates from program e
X_{ie} = no. of input i utilized by program e
Y_{1m} = no. of employed graduates from program m
X_{im} = no. of input i utilized by program m
W_1 = weight of employed graduates
V_i = weight of input
e = no. of optimization for each program
m = no. of programs
i = no. of inputs

The undergraduate programs are said to be effective if the score is one (1), but ineffective if the score is less than one. Besides using the proposed model, another model is also used as a comparison, where it deals with one (1) outcome, that is the number of employed graduates, and one (1) input which is total number of academic staff for each program. In other words, the denominator in equation (1) should be replaced with one input instead of five inputs.

RESULTS AND DISCUSSIONS

Table 1. Three effectiveness measures of 26 undergraduate programs

	Result 1: Out-come only		Result 2: 1 Out-come and 1 input		Result 3: 1 out-come and 5 inputs	
Program	Score	Rank	Score	Rank	Score	Rank
B1	81	15	0.07	24	0.32	21
B2	153	5	0.26	9	0.70	15
B3	31	24	0.08	22	0.19	24
B4	56	18	0.50	3	1.00	1
B5	342	2	0.66	2	1.00	1
B6	110	12	0.13	18	0.79	14
B7	25	25	0.06	25	0.13	25
B8	132	8	0.45	4	0.86	11
B9	53	19	0.11	20	0.44	19
B10	89	14	0.16	13	1.00	1
B11	726	1	1.00	1	1.00	1
B12	37	20	0.21	11	1.00	1
B13	139	7	0.28	8	1.00	1
B14	33	22	0.13	19	0.57	16
G15	153	5	0.28	7	1.00	1
G16	119	10	0.23	10	0.56	17
G17	18	26	0.02	26	0.11	26
G18	100	13	0.14	17	0.31	22
S19	81	15	0.16	14	1.00	1
S20	129	9	0.31	6	0.80	13
S21	222	3	0.19	12	0.54	18
S22	36	21	0.08	23	0.37	20
S23	112	11	0.35	5	1.00	1
S24	33	22	0.15	16	0.84	12
S25	156	4	0.09	21	0.20	23
S26	65	17	0.15	15	1.00	1

The summary of the results of effectiveness measures and the corresponding rankings of 26 undergraduate programs of a public university is illustrated in Table 1. It consists of 3 types of results. The first result was based directly on the number of employed students for year 2009. The second effectiveness score is based on the optimization of a ratio of one outcome to one input, without considering the different rankings of the input, while the third results was analyzed using the proposed method, which is the optimization of one outcome to five different inputs. As expected, all results are different, except program B11 which is at first position based on all the three results and G17 retained at the last position based on all three different results. The rest of the results show that the effectiveness scores and the rankings of the undergraduate programs are different among the three estimates. The proposed method estimates 10 efficient programs with score of one (1) and all are positioned at first

ranking, and the other 16 programs are inefficient with scores less than one (1). It is suggested that result 3 should be used as a basis for further analysis. Both result 1 and result 2 may be misleading because the resources used to produce the outcome were not treated in a proper manner.

CONCLUSION

This paper proposed a model to measure effectiveness of undergraduate programs by utilizing the Data Envelopment Analysis technique. Effectiveness is defined as a ratio of outcome(s) or good impact of the output to different categories of input(s). The number of employed graduates represents the outcome, while five different levels of academic staff are the inputs. Even though the selection of outcome measure is disputable, the proposed model succeeded to estimate the effectiveness of 26 undergraduate programs in a public institution for year 2009. The model can be refined by considering other long term outcome such as the performance of the employed graduates in their work setting and more suitable inputs.

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