Integrated DEA/TOPSIS Method in Evaluating Efficiency and Ranking of Academic Departments of a Public University

Nurul Iffa Nasuha Binti Abd Rahim, Nurhazirah Binti Md Yunus, Nurul ‘ Ain Binti Mohd Anour & Nur Azlina Abd Aziz*

IIntroduction

In today’s digital world, all higher education institutions face many challenges. The competition is so high that all higher education sectors especially the public universities need to function at their highest level. The reason mainly because public higher education institutions are run on taxpayers’ contributions. Therefore, top management of universities are driven to seek effective strategies for measuring and ranking their academic departments within their institutions. Data Envelopment Analysis (DEA) has been established as an effective method to measure relative efficiency of homogeneous entities known as decision making units (DMUs). Its main advantage is DEA is its ability to manage multiple inputs and outputs. However, standard DEA has some disadvantages and one of them is not being able to discriminate and rank efficient units. Standard DEA can only classify DMUs into two categories namely efficient and inefficient units and consequently, cannot provide full ranking od DMUs. Ranking academic departments are necessary and important for top management of universities so that necessary changes can be made for academic departments to move forward. The Method for Order Preference by Similarity to Ideal Solution (TOPSIS) is a standard decision-making approach with multiple attributes that are commonly used for decision-making. The advantages of the TOPSIS method are it is easy to practice and it allows the best alternative criteria to be obtained in a simple mathematical form. This paper proposed a hybrid approach based on DEA and TOPSIS techniques to overcome the problem of ranking found in standard DEA and applied it to evaluate efficiency and ranking of 22 academic departments of a public university in Malaysia from 2008 to 2010.

Methodology

There were two phases involved in this methodology. In phase 1, the efficiency scores of all academic departments were obtained via Output-Oriented CCR model. The inputs chosen were the total number of staff, the total number of full-time equivalents of student enrolment and operating expenditures, while the outputs were the total number of the degree’s awarded, the total amount of research grants, and the total number of publications. In phase 2, TOPSIS method was used to rank the efficient DMUs.

Phase 1

Due to the nature of the mission, a primal output-oriented CCR model was selected for the computations. This model was deemed acceptable as universities do not develop a direct impact on the measurement of quality. As a consequence of the extremely robust lines association of output variables with the input variable and the unfeasibility of speedily rising the results, a CRS (Constant Return to Scale) model was chosen. The output-oriented CCR model formula is as below:

$$\text{Min } \theta = \sum_{i=1}^{3} v'_{im} x_{im} \tag{1}$$

Subject to:

$$\sum_{j=1}^{3} u'_{jm}\, y_{jm} = 1$$

$$\sum_{j=1}^{3} u'_{jm} y_{jn} - \sum_{i=1}^{3} v'_{im}\, x_{in} \le 0;\ n = 1,2,\ldots,22$$

$$u'_{jm}, v'_{im} \ge 0;\ i = 1,2,3;\ j = 1,2,3$$

Phase 2

TOPSIS Method was applied to fully rank the efficient units. The steps are described below:

I. Use equation (2) to normalize the input and output (Bhattacharyya & Chakraborty, 2014).

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum_{j=i}^{m} x_{ij}^2}}, j = 1,\ldots,m, i = 1,\ldots,n \qquad (2)$$

II. Using the CRITIC method, calculate the weight of DMUs as follows:

Step 1:

Find the standard deviation for each column in the DMU Normalized Value table. To calculate the standard deviation by using equation (3)

$$SD = \sqrt{\frac{\sum|x-\mu|^2}{N}} \qquad (3)$$

Step 2:

Determine the symmetric matrix of (n x n) with an element (r_{jk}), where r_{jk} represents the linear correlation coefficient between the vectors z_j, and z_k.

$$X = \begin{bmatrix} z_{11} & \cdots & z_{i1} & \cdots & z_{m1} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ z_{1j} & \cdots & z_{ij} & \cdots & z_{mj} \\ \vdots & \ddots & \vdots & \ddots & \vdots \\ z_{1n} & \cdots & z_{in} & \cdots & z_{mn} \end{bmatrix} \qquad (4)$$

$j = 1, \ldots m$

$i = 1, \ldots n$

Where z_{ij} denotes the decision matrix element for the jth alternative in the ith attribute.

Step 3:

Calculate the measure of the conflict created by criterion j in relation to the decision situation defined by the remaining criteria.

$$\sum_{k=1}^{m}(1 - z_{ij}) \tag{5}$$

Step 4:

Identify the objective weights:

$$C_j = SD * \sum_{k=1}^{m}(1 - z_{jk}) \tag{6}$$

$$W_j = \frac{c_j}{\sum_{k=1}^{m}(c_j)} \tag{7}$$

III. Use equation (8) to compute the weighted normalized decision matrix:

$$v_{ij} = n_{ij}w_{ij}, j = 1, \dots, m, i = 1, \dots, n \tag{8}$$

IV. Find positive and negative optimal solutions. If the input and output are reduced, performance will increase. The forms of positive ideal solution A^+ and negative ideal solution $A^-$are shown in equation (9) and (10) respectively.

$$A^+ = \{v_1^+, \dots, v_n^+\} = \{(max_j\ v_{ij} \mid i \in I), (min_j\ v_{ij} \mid i \in J)\} \tag{9}$$

$$A^- = \{v_1^-, \dots, v_n^-\} = \{(min_j\ v_{ij} \mid i \in I), (max_j\ v_{ij} \mid i \in J)\} \tag{10}$$

V. Determine the distance between each option and the positive and negative optimal solutions using the Euclidean distance formula. The formula is as follows:

$$d_j^+ = \sqrt{\sum_{i=1}^{n}\left(v_{ij} - v_i^+\right)^2}, \quad j = 1, \dots, m \tag{11}$$

$$d_j^- = \sqrt{\sum_{i=1}^{n}\left(v_{ij} - v_i^-\right)^2}, \quad j = 1, \dots, m \tag{12}$$

VI. Rank the DMUs according to the distance between the positive and negative optimal solutions. DMUs that are close to the optimal solution will outperform DMUs that are far from the optimal solution. The distance is calculated as follows:

$$S_j = \frac{d_j^-}{d_j^+ + d_j^-} \quad , \qquad j = 1, \dots, m \tag{13}$$

The closer S_j is to 1, the higher the rank of the alternative *j*th.

Results and Discussion

The hybrid DEA/TOPSIS technique was able to rank all efficient units. The comparison between ranking obtained via standard DEA and hybrid DEA-TOPSIS is shown in Table 1. The results showed that 9, 12 and 9 DMUs emerged as efficient units in 2008, 2009 and 2010 respectively. DMU10 and DMU11 obtained top three ranking for three consecutive years. This implied that all inefficient DMUs should learn practices and strategies adopted by DMU10 and DMU11 to become efficient.

Conclusion

The proposed DEA-TOPSIS method has successfully fully ranked all DMUs under study. The findings can help the university's top management in short-term and long-term planning to improve performance of its academic departments. Also, the findings allow the university decision makers to redefine guidelines and policies in the university to improve efficiencies of its academic departments.

Table 1: Complete rankings of DMUs for the years 2008, 2009, and 2010 respectively by using DEA and DEA/TOPSIS method

DMUs	Complete ranking for the year 2008		Complete ranking for the year 2009		Complete ranking for the year 2010	
	Using DEA	Using DEA/TOPSIS	Using DEA	Using DEA/TOPSIS	Using DEA	Using DEA/TOPSIS
DMU1	1	4	1	5	1	3
DMU2	20	20	19	19	12	12
DMU3	15	15	1	6	1	8
DMU4	1	9	17	17	16	16
DMU5	1	5	1	8	18	18
DMU6	14	14	14	14	13	13
DMU7	1	1	1	1	1	4
DMU8	21	21	21	21	21	21
DMU9	17	17	20	20	20	20
DMU10	1	3	1	2	1	1
DMU11	1	2	1	3	1	2
DMU12	1	8	1	7	1	6
DMU13	1	6	1	9	1	7
DMU14	13	13	1	4	1	5
DMU15	1	7	13	13	17	17
DMU16	19	19	18	18	19	19
DMU17	16	16	15	15	14	14
DMU18	11	11	1	12	10	10
DMU19	12	12	1	10	1	9
DMU20	10	10	16	16	11	11
DMU21	22	22	22	22	22	22
DMU22	17	17	1	11	15	15

References

Bhattacharyya, A., & Chakraborty, S. (2014). A DEA-TOPSIS-based approach for performance evaluation of Indian technical institutes. *Decision science letters*, *3*(3), 397-410.