International Journal for Modern Trends in Science and Technology
Volume: 03, Issue No: 02, February 2017
ISSN: 2455-3778
http://www.ijmtst.com

Comparing Two Multi-Criteria Approaches to Investigate Their Ability in Measuring Efficiency

Ramadan A.ZeinEldin[1] | Bandar M.Abdullah[2]

[1]Deanship of Scientific Research, King AbdulAziz University, Jeddah, Kingdom of Saudi Arabia; Operations Research Department, ISSR, Cairo University, Egypt.
[2]Deanship of Scientific Research, King AbdulAziz University, Jeddah, Kingdom of Saudi Arabia

To Cite this Article
Ramadan A.ZeinEldin and Bandar M.Abdullah, "Comparing Two Multi-Criteria Approaches to Investigate Their Ability in Measuring Efficiency", *International Journal for Modern Trends in Science and Technology*, Vol. 03, Issue 02, 2017, pp. 52-56.

ABSTRACT

This paper investigates the ability of two well-known and well-used multi-criteria approaches in measuring the efficiency and show the advantages and disadvantages of each approach. The two approaches are Data Envelopment Analysis (DEA) and Simple Additive Weighting (SAW). From the literature, the research related to the two approaches is increasing largely nowadays. Most of the researchers begin to merge other features or other methods with the two approaches like fuzzy DEA and fuzzy SAW. A universities evaluation real case is used to check the ability of the two approaches. From the real case, it is very clear that SAW can really measure efficiency but DEA just says which alternative is efficient and which is not.

KEYWORDS: *DEA, SAW, Efficiency, Comparing, Universalities*

I. INTRODUCTION

Universities play an important role in the society; beside building graduates mental capacities, they have an important role in research and building the capacity of all the society. The main role of universities is creating economically valuable intellectual resources. In the last two decades, higher education worldwide has moved from the periphery to the centre of governmental agendas. Universities are now seen as crucial national assets in addressing many policy priorities, and as: sources of new knowledge and innovative thinking; providers of skilled personnel and credible credentials; contributors to innovation; attractors of international talent and business investment; agents of social justice and mobility; contributors to social and cultural vitality; and determinants of health and well-being [1]. Universities play an important role in the social and economical development of a country. Therefore, governments usually provide the financial resources universities need. On the other hand, universities should be efficient in satisfying the government's conditions of functional resources. Universities take a ratio of the country budget to cover their expenses and all the countries all over the world have many universities which they are public or private universities. So, it is very important to evaluate the positions of each country's universities locally and globally. The most used techniques to evaluate the positions of universities are the multi-criteria approaches such as DEA, SAW, TOPSIS, and other methods.

DEA is a powerful method widely used in the evaluation of performance of Decision Making Units (DMUs). DMUs can be business units, government agencies, police departments, hospitals, educational institutions, and even people. DEA have been used in the assessment of

athletic, sales and student performance [2].

SAW method is one of the simplest and most widely used multi-criteria evaluation methods. It integrates the values and weights of criteria into a single estimating value – the criterion of the method [3]. The basic idea of SAW method is that the overall ranking index for each alternative is calculated as the sum of products of its responses and corresponding significance coefficient of objectives. SAW assumes additive aggregation of decision outcomes, which is controlled by weights expressing the importance of criteria [4].

The objective of this paper is to measure the efficiency of some universities and rank these universities according to their efficiency values. Also, to check the ability of DEA and SAW approaches in measuring the efficiency. The rest of the article is as follow; DEA is described in section 2, section 3 is assigned to SAW approach. The universities application and comparing between the two approaches is done in section 4, finally, conclusions and points for future research are mentioned in section 5.

II. Data Envelopment Analysis (DEA)

The use of the DEA approach not only allows us to compare individual firms to best practice firms, but also to identify sources of inefficiency (in the inputs and outputs). Such benefits allow decision makers and regulators to formulate policies on deregulation and privatization, and to determine the appropriate productivity factor when imposing other factors. DEA is based on linear programming methods that have been applied to measure the productivity of some units in the same industry and follow the same regulations and rules. It can be used to measure the productivity of the power sector, insurance sector, banking and other sectors in any country. Unlike parametric analyses, which focus on generation, both generation and transmission and distribution have been covered in studies using the DEA approach [5]. The mathematical model of this method is as follows ([6-8],[2]):

$$w_k = \max \frac{\sum_{r=1}^{s} u_r y_{rk}}{\sum_{i=1}^{m} v_i x_{ik}}$$

s. t.

$$\frac{\sum_{r=1}^{s} u_r y_{rj}}{\sum_{i=1}^{m} v_i x_{ij}} \le 1; \quad j = 1, \ldots, n \qquad (1)$$

$$u_r, v_i \ge 0; \quad r = 1,\ldots,s; \quad i = 1,\ldots,m$$

where j is the DMU index, $j = 1, \ldots, n$; r the output index, $r = 1,\ldots,s;$ i the input index, $i = 1,\ldots,m$; x_{ij} is the value of i^{th} input for the jth DMU, y_{rj} is the value of r^{th} output for the jth DMU, v_i is the weight given to the *i-th* input, u_r is the weight given to the *r-th* output, and *k* is the DMU being measured. In this model DMU_k is efficient if and only if $w_k = 1$.

By using Charnes and Cooper's transformation, the above fractional programming model is equivalently converted into the linear programming (LP) below for solution:

$$w_k = \text{Maximize} \sum_{r=1}^{s} u_r y_{rk}$$

Subject to:

$$\sum_{i=1}^{m} v_i x_{ik} = 1, \qquad (2)$$

$$\sum_{r=1}^{s} u_r y_{rj} - \sum_{i=1}^{m} v_i x_{ij} \le 0;$$

$$j = 1, \ldots, n; \quad u_r, v_i \ge 0; \quad r = 1,\ldots,s; \quad i = 1,\ldots,m$$

In model (2), the weighted sum of the inputs for the target DMU is forced to 1, thus allowing for the conversion of the fractional programming problem into a linear programming problem. The linear programming model can be formulated as maximize for output criteria as in model (2) and can be formulated as minimize for the input criteria.

A DMU is considered individually in determining its relative efficiency. This DMU is referred to as the target DMU. The target DMU effectively selects weights that maximize its output to input ratio, subject to the constraints that the output to the input ratios of all the n DMUs with these weights are ≤1. If the optimal objective function value turns out to be one, then DMU_k is said to be DEA efficient; otherwise, it is said to be non-DEA efficient. The LP model is solved *n* times in total, each time for one DMU. As a result, at least one DMU is evaluated as DEA efficient, but very often more than one DMU proves to be DEA efficient. The

DEA model can be divided into an input-oriented and an out-oriented model, depending on the reason for conducting DEA. The input-oriented model is to minimize inputs with given outputs, whereas the output-oriented model is to maximize outputs with given inputs [6] and [9]. Noh [8] used DEA to measure the efficiency of university libraries. There are a lot of research in the literature using a DEA to measure the performance of units in many sectors such as El-Razik [2] used DEA to assess the performance of nineteen Saudi Arabia universities.

III. Simple Additive Weighting (SAW)

SAW is developed by MacCrimon in 1968, SAW is also known as the weighted linear combination, scoring method, or weighted sums [10]. SAW is one of the most used MCDM techniques. It is simple and can be seen as the basis of most MCDM techniques such as AHP and PROMETHEE that benefits from additive property to calculate final scores of alternatives [11]. SAW uses the principle of weighted average in which a scaled value is given for each alternative by an attribute then multiplied by their respective weight assigned by the decision maker. De Brito and Evers [12] defined SAW as a tool that aims to determine a weighted score for the alternatives by adding each attribute multiplied by their weights. Podvezko [13] presented a brief history of origin and the development of SAW method.

SAW Steps:

SAW procedure consists of the following steps ([3]- [4], [10], [13]-[14]):

Step 1: Construct a decision matrix (mxn) that includes m alternatives and n criteria.

Step 2: Calculate the normalized decision matrix for positive (benefit) criteria:

$n_{ij} = \frac{r_{ij}}{r_j^{max}} i = 1,2,\dots,m, \quad j = 1,2,\dots,n.$ Where r_j^{max} Is a maximum number of r in the column of j.

And for negative (cost) criteria:

$n_{ij} = \frac{r_j^{min}}{r_{ij}} i = 1,2,\dots,m, \quad j = 1,2,\dots,n$

where r_j^{min} is a maximum number of r in the column of j.

Step 3: Evaluate each alternative, A_i by the following formula:

$$A_i = \sum w_j \, n_{ij}$$

Then ranking alternatives according to the values of A_i, the alternative with the highest score is selected as the preferred one.

Step 4: rank the alternatives according to their efficiency from the highest value to the lowest value.

Abdullah and Adawiyah [15] presented a review of the applications of SAW and fuzzy SAW from 2003 to 2013 (a decade). Thor et al. [16] reviewed and compared the methods AHP, ELECTRE, SAW, and TOPSIS in maintenance decision making. Shakouri [4] applied DEA and SAW to compare the same fossil fuel (coal) power plants with nuclear power plants. Setyani and Saputra [14] used SAW to determinate suitable flood-prone areas. Chou et al. [17] used fuzzy SAW for solving the facility location selection problem under a fuzzy environment. Wang [18] proposed a fuzzy multi-criteria decision making model that combines SAW with the relative preference relation to solve fuzzy problems. Hojjati and Anvary [19] proposed an integrated algorithm of SAW–TOPSIS with an aggregate method "Borda" to select lean tools. Afshari et al. [10] used SAW to solve personal selection problem. Sagar et al. [20] used fuzzy SAW to select maintenance strategy. ZeinEldin [3] built a DSS based SAW and TOPSIS to measure the efficiency and rank some Egyptian drug companies.

IV. Comparing the Two Approaches

In this section, we use a real case of 10 universities to check the ability of DEA and SAW in measuring the efficiency. The DEA and SAW approach steps are applied to measure the efficiency of the universities to rank them.

A. DEA:

The concept of DEA is to classify the criteria into Input criteria and output criteria. We reviewed some research in ranking universities and negotiated with some of the decision makers in some universities to determine the suitable criteria and which is the input and which is the output. Table 1 shows the input and output criteria used in DEA. Table 2 shows the efficiency score got using DEA using Banxia Frontier Analyst software.

Table 1: Input and output criteria for DEA

Input criteria	Output criteria
Staff	Number of total students
Number of colleges	Number of Post-graduate students
The budget	Number of international published articles in Journals
	Number of conferences that the staff participated in

Table 2: The Universities efficiency scores

DMUs	Score	Efficient
University 1	100%	Yes
University 2	100%	Yes
University 3	100%	Yes
University 4	100%	Yes

University 5	100%	Yes
University 6	100%	Yes
University 7	78.47%	Not
University 8	100%	Yes
University 9	100%	Yes
University 10	100%	Yes

From table 2, we note that nine universities (of Ten universities) are efficient. What does the word "efficient" mean? From the basic concepts of DEA, it means relative efficiency i.e. they are good. I can't convince the decision maker with this result. Surely, he needs to classify or rank the "good" or efficient universities. This is a great disadvantage of DEA as a multi criteria approach, although DEA provides other information about the possible improvements in each criteria whatever it is input or output and the peer contribution.

B. Saw:

The steps of SAW mentioned in section 3 are applied on the same case. Table 3 shows the 10 universities rank according to SAW approach. SAW computes efficiency value for each university based on weights determined in an interactive approach with the problem owner or decision maker. In this case, weights are determined by reviewing some research articles, global universities ranking web sites and consulting some experts in some universities. An Excel sheet is used to implement SAW approach. Table 3 shows the final output of SAW approach.

Table 3: Universities rank using SAW

DMUs	Efficiency	Rank
University 1	0.699802	1
University 3	0.691059	2
University 2	0.495223	3
University 6	0.440148	4
University 5	0.403226	5
University 8	0.382615	6
University 7	0.371773	7
University 4	0.350261	8
University 10	0.324788	9
University 9	0.311574	10

From table 3, it is clearly noted that the universities are ranked in logical way and the decision maker is aware with the universities positions and can take some decisions to improve the universities positions.

V. Conclusions and Points for Future Research

Because This article aimed to investigate the ability of two multi-criteria approaches; DEA and SAW in measuring the efficiency and ranking. From a real universities case, it is found that DEA just given which universities are efficient and which are not. But SAW computed the efficiency value for each university and ranked them according to the efficiency value. This point is very important and it is considered as an advantage to SAW and disadvantage to DEA. As points for future research; the algorithm of DEA can be updated to measure the efficiency of DMUs as values not 1 (efficient) or between 0 and 1 (inefficient). Also, SAW algorithm can be updated in determining the weight values because sometimes the decision maker cannot determine the weights. Determining the weights is the main core step of SAW approach.

References

[1] G. Boulton, "GLOBAL: What are universities for?", University world news, No. 69, March, 2009. Available: http://www.universityworldnews.com/article.php?story=20090326200944986

[2] E. A. El-Razik, "Data Envelopment Analysis a Technique for Measuring Efficiency", British Journal of Mathematics & Computer Science, vol. 5, no. 6, pp. 763-779, 2015.

[3] R. A. ZeinEldin, "A Decision Support System for Performance Evaluation", IJCA Special Issue on "Computational Intelligence & Information Security" CIIS 2012, pp. 1-8, 2012.

[4] H. Shakouri, M. Nabaee, S. Aliakbarisani, "A quantitative discussion on the assessment of power supply technologies: DEA (data envelopment analysis) and SAW (simple additive weighting) as complementary methods for the "Grammar"", Energy, vol. 64 pp. 640-647, 1 Jan. 2014.

[5] PL. Lam and A. Shiu, "A data envelopment analysis of the efficiency of China's thermal power generation", Utilities Policy, vol. 10, no. 2, pp. 75–83, June 2001.

[6] H. Seol, J. Choi, G. Park, and Y. Park, "A framework for benchmarking service process using data envelopment analysis and decision tree", Expert Systems with Applications, vol. 32, no. 2, pp. 432–440, Feb. 2007.

[7] H. Bal, and H. ÖRKCÜ, "A Goal Programming Approach to Weight Dispersion in Data Envelopment Analysis", Gazi University Journal of Science, vol. 20, no. 4, pp. 117-125, 2007.

[8] Y. Noh, "Evaluation of the resource utilization efficiency of university libraries using DEA techniques and a proposal of alternative evaluation variables", Library Hi Tech, vol. 29, no. 4, pp. 697 – 724, 2011.

[9] YM. Wang, Y. Luo, and L. Liang, "Ranking decision making units by imposing a minimum weight restriction in the data envelopment analysis",

Journal of Computational and Applied Mathematics, vol. 223, no. 1, pp. 469–484, 1 Jan. 2009.

[10] A. Afshari, M. Mojahed and R. M. Yusuff, "Simple Additive Weighting approach to Personnel Selection problem", International Journal of Innovation, Management and Technology, Vol. 1, No. 5, pp. 511-515, Dec. 2010.

[11] A. Alinezhad, K. Sarrafha, and A. Amini, "Sensitivity Analysis of SAW Technique: the Impact of Changing the Decision Making Matrix Elements on the Final Ranking of Alternatives", Iranian Journal of Operations Research, Vol. 5, No. 1, pp. 82-94, May 2014.

[12] M. M. de Brito and M. Evers, "Multi-criteria decision-making for flood risk management: a survey of the current state of the art", Nat. Hazards Earth Syst. Sci., 16, no. 4, pp. 1019–1033, April 2016.

[13] V. Podvezko, The Comparative Analysis of MCDA Methods SAW and COPRAS, Engineering Economics, vol. 22, no. 2, pp. 134-146, 2011.

[14] RE. Setyani, and R. Saputra, "Flood-prone Areas Mapping at Semarang City By Using Simple Additive Weighting Method", Procedia-Social and Behavioral Sciences, vol. 227, pp. 378 – 386, July 2016.

[15] L. Abdullah and C.W. R. Adawiyah, "Simple Additive Weighting Methods of Multi criteria Decision Making and Applications: A Decade Review", International Journal of Information Processing and Management, vol. 5, no. 1, pp. 39-49, Feb. 2014.

[16] J. Thor, SH. Ding, and S. Kamaruddin, "Comparison of Multi Criteria Decision Making Methods From The Maintenance Alternative Selection Perspective", The International Journal Of Engineering And Science, Vol. 2, no. 6, pp. 18-25, 2013.

[17] SY Chou, YH Chang, and CY Shen, "A fuzzy simple additive weighting system under group decision-making for facility location selection with objective/subjective attributes", European Journal of Operational Research, vol. 189, no. 1, pp. 132–145, Aug. 2008.

[18] YJ Wang, "A fuzzy multi-criteria decision-making model based on simple additive weighting method and relative preference relation", Applied Soft Computing, vol. 30, pp. 412–420, May 2015.

[19] S.M.H. Hojjati and A. Anvary, "An Integrated SAW, TOPSIS Method for Ranking the Major Lean Practices Based on Four Attributes", World Applied Sciences Journal, vol. 28, no. 11, pp. 1862-1871, 2013.

[20] M. K. Sagar, P. Jayaswal, and K. Kushwah, "Exploring Fuzzy SAW Method for Maintenance Strategy Selection Problem of Material Handling Equipment", International Journal of Current Engineering and Technology, vol. 3, no. 2, pp. 600-605, June 2013.