Multi-Criteria Decision Making for Ranking Decision Making Units

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ABSTRACT

There is no doubt the Data Envelopment Analysis (DEA) is a powerful method for the efficiency evaluation of Decision Making Units (DMUs) with multiple inputs and outputs. Despite its usefulness, DEA has some notable limitations. A significant drawback with this approach is that inability to fully rank the DMUs. In the extant literature, different methods for this purpose have been suggested. While, in the traditional method the first step for the DEA approach is used, and results of this step are input for the DEA ranking method in the second step. To reduce the computational complexity of the traditional method, a new Multiple Criteria Decision Making (MCDM) approach is proposed in this article. In the proposed approaches, one step can achieve full ranking for all DMUs. The results show that although out of 20 DMUs are first in the final ranking ordered by the DEA, the author proposed methods can consider full ranking. Agreement of the proposed methods with the existing approaches are measured by the Spearman’s rank correlation coefficient technique. The findings of this study reveal that TOPSIS, Neo-TOPSIS, and AHP ranking results are consistent with the DEA ranking method. Therefore, these proposed methods appear as the possible alternatives to the DEA and DEA ranking models.

KEYWORDS

DEA, Efficiency Evaluation, MCDM, Ranking Efficient DMUs, Relative Efficiency

1. INTRODUCTION

The attainment of high levels of performance is a key issue for the success of every organization. Therefore, an adequate management framework is necessary for evaluating the current performance, identifying benchmarks to use in seeking improvements, and understanding why some units in a particular organization are operating (in)efficiently. In the extant literature, Data Envelopment Analysis (DEA) models have been extensively used to assess the performance of Decision Making Units (DMUs) in a broad range of real-world problems (Madlener, Antunes, & Dias, 2006). DEA, a nonparametric technique, is an alternative to multivariate statistical methods when it is used for the data with multiple inputs and outputs. DEA provides researchers a wide usage opportunity since it does not require any assumptions, unlike multivariate statistical methods, and it has the flexibility to add new restrictions to model according to researcher’s needs.

The DEA is a method for mathematically comparing differences in DMU productivity based on multiple inputs and outputs. The ratio of weighted inputs and outputs produces a single measure of
productivity called relative efficiency. The DMUs that have a ratio of 1 are referred to as “efficient”, given the required inputs and produced outputs. The units that have a ratio less than 1 are “less efficient” relative to the most efficient units. Because the weights for the input and the output variables of DMUs are compared to maximize the ratio and then compared to a similar ratio of the best-performing DMUs, the measured productivity is also referred to as “relative efficiency” (Rouyendegh, 2011).

However, DEA is a very powerful tool for the efficiency evaluation of decision-making units with multiple inputs and outputs. One of its shortcomings is its inability to fully rank the decision-making units. Ever since it was created by Charnes, Cooper, and Rhodes on the basis of Farrel, the question of full ranking has been in the forefront of research (Fulop & Somogyi, 2012).

As noted earlier, efficient DMUs are identified by an efficiency score equal to 1, and inefficient DMUs have efficiency score less than 1. Although efficiency scores can be a criterion for ranking inefficient DMUs, this criterion cannot rank efficient DMUs. During the last decade, a variety of methods were developed to rank DMUs. While each technique (method) is useful in a specific area, no one methodology can be prescribed to possess as a complete solution the question of ranking. Hence, selecting the best ranking method or the way of combining different ranking methods for ranking DMUs is an important point in ranking DMUs in DEA (Lotfi, Fallahnezhad, & Navidi, 2011).

However, Fulop and Somogyi (2012) believe that Multiple Criteria Decision Making (MCDM) methods can also be combined with DEA to provide full ranking. Since then, several efforts have been made to combine or employ in parallel DEA and an MCDM method. Additionally, according to the viewpoint proposed by Stewart (1996), DEA and MCDM are two of the more important branches of management science to have emerged beyond the traditional emphasis on mathematical tools, such as Linear Programming, to tools of decision support and problem structuring. Furthermore, some authors even argue that DEA itself is a MCDM technique (Somogyi, 2011).

MCDM refers to making preference decisions (e.g., evaluation, prioritization, and selection) over the available alternatives that are characterized by multiple, usually conflicting, criteria (Yucenur & Demirel, 2012). Nevertheless, DEA arises from situations where the goal is to determine the productive efficiency of a system or DMU by comparing how well these units convert inputs into outputs, while MCDM models have arisen from problems of ranking and selecting from a set of alternatives that have conflicting criteria. A methodological connection between MCDM is to define maximizing criteria (benefits) as outputs and minimizing criteria (costs) as inputs (Sarkis, 2000).

In this article, we address the ranking of efficient and inefficient DMUs by using MCDM approaches (i.e., TOPSIS and Neo-TOPSIS methods; the Weighted Sum Model (WSM), Analytic Hierarchy Process (AHP), Revised AHP, Weighted Product Model (WPM) and Multiplicative AHP, based on benefit to cost ratio approach; and an extended version of the WPM method) of which some had never been considered previously. In the proposed methods, input and output play the role of cost and benefit, respectively.

The article is organized as follows. The second section contains the Literature Review and the third section discusses the proposed approach. A numerical example is provided in the following section and the last section contains the Conclusion.

2. LITERATURE REVIEW

DEA models are widely recognized and applied to various industrial and non-industrial decision-making contexts. Evaluation of information system projects, ranking of data mining association rules, efficiency assessment of bank branches, designing of facility layouts in manufacturing systems, and evaluation of data warehouse operations are examples of applications of DEA in various contexts (Sohrabi, Toloo, Mocini, & Nalchigar, 2015). However, Garg, Agarwal, and Choubey (2015) state that MCDM is a very practical method the real world, and has a significant effect on both theory and practice. Therefore, several efforts have been made in the extant literature to combine or employ in parallel DEA and a MCDM method (Somogyi, 2011).
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