A Robust Data Envelopment Analysis Method with Bounded Data for Ranking Operations Strategies

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ABSTRACT

This paper introduces a new robust data envelopment analysis (RDEA) approach for analyzing and ranking the organizations' operations strategies. In the proposed RDEA method, pessimistic and optimistic efficiencies of decision making units (DMUs) obtained from the robust counterpart of the envelopment form and the optimistic counterpart of the multiplier form of DEA are introduced. The inputs and outputs data are assumed to be bounded data (interval numbers) in the proposed models. A case study in the cement industry is presented to demonstrate the applicability of the proposed RDEA approach. The results obtained from the authors' proposed RDEA approach is more robust and their method provides a more complete ranking of the DMUs compared to conventional Likert-based DEA model.

Keywords: *Bounded Data, Cement Industry, Likert Scale Data, Operations Strategy, Ranking, Robust DEA*

1. INTRODUCTION

In the brutal business competitive environment, the success of a company greatly depends on the effectiveness of its operations strategy (Boyer and Pagell, 2000; Boyer and Lewis, 2002; Slack and Lewis, 2011). Whereas the function of the operations strategy in the organization is to make a balance between market requirements and organization operations resources, it is very important for a company to focus on its operational performance in comparison to its rivals (Kaviani et al. 2014). For this purpose, organizations should evaluate the effectiveness of their operations strategies by assessing the efficiencies of their operational performances. Furthermore, companies are able to pursue the competitive edge of their markets through monitoring the operational performance of their rivals. Since the operational performance is linked inseparably

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to the operations strategy, analyzing the organizations' operations strategies can be useful for the mangers in terms of finding out their positions in comparison to their competitors (Kaviani and Abbasi, 2014). Hence, in this study we aim to present a ranking method for analyzing the efficiencies of the companies' operations strategies based on their operational performance. Due to this purpose, we need a powerful method for efficiency evaluation.

DEA as a famous efficiency estimation method was proposed first by Charnes et al. (1978) and was developed by Banker et al. (1984). Conventional DEA models were suggested for the precise data and they didn't have the ability to deal with the uncertain data. Since the existence of vague and ambiguous data is inevitable in real world problems, uncertain DEA models proposed and applied by many researchers. Grey DEA, Fuzzy DEA, Imprecise DEA, Stochastic DEA and Robust DEA have been used more than other uncertain DEA methods in the recent researches. Robust optimization was introduced by Ben-Tal and Nemirovski (1998, 1999) and under controllable uncertainty conditions by Bertsimas and Sim (2004, 2006). Ben-Tal and Nemirovski (2000) presented a robust optimization approach for a mathematical programming problem in a linear environment. They demonstrated that very small deviation in the data can lead to unjustified answers and this is why the conventional DEA models with certain data are not reliable. Recent advances in robust optimization and their applications to DEA models resulted to produce new rankings which can change the results by small changes in input and output data. Consequently rankings obtained by these methods are reliable. Robustness means that the output is not very sensitive to the pattern inputs and the exact amounts of parameters. Robust optimization is an alternative for sensitivity analysis and random programming and it has some major advantages like applicability and flexibility. Thus, in this method, some percentage of deviation is assumed in the data, and then the robustness of estimated efficiency will be obtained.

In this paper we use DEA as a non-parametric tool for efficiency evaluation of the firms' operations strategies. It is considerable that in DEA model of this research, we use five competitive advantages (performance objectives) consist of cost, quality, flexibility, dependability and speed as input variables and market share, Return On investment (ROI) and Return on assets (ROA) as outputs according to Kaviani and Abbasi's (2014) study. Given that data of these inputs and outputs are associated with the uncertainty, we use a RDEA approach as an uncertain DEA model in this study. In other words, the main objective of this study is to evaluate and rank the firms' operational performances in comparison to their competitors based on the effectiveness of their operations strategies by using a proposed RDEA method.

This paper has two clear contributions. The theoretical contribution of this study is that we use RDEA for an operational performance evaluation problem. Moreover, the methodological contribution of the current study is that we propose a new RDEA approach to evaluate the efficiency of DMUs by using bounded data through the optimistic and pessimistic viewpoints. We develop DEA model based on the robust optimization approach of Beck and Ben-Tal (2009). From a pessimistic view, each DMU is evaluated under the worst conditions and from the optimistic view a DMU is evaluated under the best conditions. For this purpose, robust envelopment form of DEA model is presented for the pessimistic efficiency and the robust dual multiplier form of DEA model is proposed to calculate the optimistic efficiency of each DMU applying interval numbers.

The rest of the paper is organized as follows: In the next section we investigate the related studies and show the research gap. In section 3, we introduce our proposed RDEA approach which uses bounded data and Chen et al. (2015) DEA model which applies Likert scale data. After that, in section 4, we demonstrate the applicability of our proposed RDEA approach through a practical case in Iran cement industry. We compare the obtained results from RDEA and Likert-based DEA in section 5. Finally the paper ends with the concluding remarks in section 6.