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A TOPSIS based design of experiment approach to assess company ranking

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ABSTRACT

Company ranking is a complex process in which multiple financial ratios are required to be considered simultaneously. Furthermore, the selection process of an appropriate credit applicant company has become more complex as the experts in the financial organizations have to assess a wide range of alternatives based on a set of conflicting financial criteria. This paper studies the application of a new approach, i.e., Design of Experiment and TOPSIS method (DoE–TOPSIS) together to make company raking as frequently encountered in the real-time financial environment. The developed model is tested by case studies and satisfactory results are obtained. In the case studies, the results obtained by using the combined DoE–TOPSIS method are almost corroborated by those derived from conventional multi attribute decision making (MADM) methods which prove the applicability, potentiality, simplicity and flexibility of this method in making company ranking.

1. Introduction

The financial performance of a company during a specific period of time is usually evaluated by various financial ratios collected from its financial statements; such as a balance sheet, an income statement and cash flow [1]. These ratios provide useful information to the financial institutions or commercial banks, and reflect the company's financial performance from various perspectives [2]. The overall financial performance of companies competing with each other cannot be appropriately evaluated or ranked without simultaneous consideration of all these conflicting financial ratios [1].

On the other hand, financial analysis of companies is a complex process, in which multiple financial ratios are required to be considered simultaneously. A company puts the traditional financial analysis approach through the process; financial experts prepare a financial analysis report. This traditional approach used for evaluating a company's financial performance is a financial statement analysis based on the computation of financial ratios [1]. A financial analysis report includes a subjective analysis of the company in terms of its financial position which affects revenues and expenses of the company. This method is no longer sufficient in today's dynamic business environment because of its unrealistic assumptions and its dependency on an expert's subjective opinion. In addition, an analysis of a company is time-consuming for financial institutions.

However, several studies used financial ratios in developing credit models in the literature. For example, Altman and Saunders [15] developed a discriminating analysis model in which financial ratios are combined and weighted to produce a credit score. In other studies, multivariate statistical and econometric analysis techniques, such as the linear probability model and the logit regression model [16,17], are used for company rating [6]. Detailed comparisons and discussions of the credit scoring models are proposed in the literature, i.e.; soft-computing approaches, non-parametric statistical methods, and parametric statistical methods [6,18–24,25]. The main disadvantage of the statistical techniques used in company rating

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is that high number of companies are in default of that is required. Therefore, the default functions determined by using these techniques have a restricted predictive capacity [24,25].

Alternatively, MADM (multi-attribute decision making) methods are widely used in evaluating the financial performance or company ranking studies from a set of available alternatives with respect to the conflicting criteria. In the literature, financial ratios are incorporated into MADM models such as Analytic Hierarchy Process (AHP) [3,4], Technique for Order Preference by Similarity to Ideal Solution (TOPSIS) [1,5–7], Data Envelopment Analysis (DEA) [8–10], PROMETHEE [11,12], COPRAS (Complex Proportional Assessment) [13], SAW (Simple Additive Weighting) [13], and VIKOR-VlseKriterijumska Optimizacija Kompromisno Resenje [14]. MADM methods provide an effective way for inter-company comparison including the evaluation of multiple financial ratios. It can rank companies competing with each other in terms of their overall performances [1].

However, MADM methods offer certain drawbacks. One of the major problems is the rank reversal phenomenon. MADM methods can produce "rank reversal" outcomes, as several authors have described [27–29]. In this phenomenon, ranking scores of the alternatives change when a new alternative is added to or removed from the multi-attribute decision making problem. On the other hand, the weights of experts' opinions play an important role in the multiple attribute groups decision-making (MAGDM); how to integrate the weights of individual experts is a hot research topic. The increasing difficulty of the social and economical problems in society makes it less possible for the single expert to consider all relevant properties of a problem. In the real world, many MADM approaches take place in the group work [30]. Moving from a single expert's setting to a group experts' setting appears a great deal of difficulty into the multi-attribute decision making process. In the real world problems, these experts generally come from different specialty environments, and thus each expert has a unique capability in terms of skills, personality, experience, and knowledge, and this situation implies that an expert generally has a different influence in the overall decision result [30]. Hence, determining the unique weight set for experts will be an important research topic in the multi attribute decision making environment.

The main purpose of this paper is to propose a novel DoE–TOPSIS approach to solve the multi-attribute company ranking problems. In this paper, we also study the rank reversal phenomenon in the MADM methods, and we propose a new TOPSIS based on the design of experiment methodology in order to solve the problem. Moreover, we present a general demonstration of the proposed DoE–TOPSIS methodology in the multiple attribute group decision-making problems, a numerical example to show this demonstration as well.

By considering a relevant set of financial ratios, the proposed DoE–TOPSIS methodology presents a model to estimate the regression equation, which allows for a set of companies to be ranked according to their performance level. The regression equation is obtained by using the integrated DoE and TOPSIS approach. When the regression equation is obtained, the alternative evaluation process can be easily facilitated. It is different from the traditional MADM approaches that require the inputs of attributes' weights for an alternative evaluation. The developed model should also be easy to use, expandable, adaptable and modifiable for different decision situations. Six illustrative examples are also analyzed in this study.

The paper is organized as follows: In Sections 2 and 3, the DoE–TOPSIS application steps are presented. In Section 4, examples are illustrated. In Section 5, the conclusions are presented.

2. DoE–TOPSIS application

DoE method and TOPSIS have been well known in the literature. DoE is a statistical technique used to study the effect of several factors simultaneously. The DoE technique is used to determine independent and interaction effect of multiple factors on performance [31,32]. However, DoE has a substantial field of application in manufacturing systems and quality applications [33–41]. On the other hand, TOPSIS is a well known MADM technique because it has a simple and successful computation procedure [42–46]. Details of the DoE technique and TOPSIS method are presented in Montgomery [31], Sandanayake [32], Yang and Lu [34], Yang et al. [35], Lu et al. [36], Ic [43], Tsaur [44], Mahdavi et al. [45], Yue [30,46], Jahanshahloo et al. [47,48], and Shyur [49].

As the individual methods (DoE and TOPSIS) of this study are not unique, the combination of these methods has not ever been presented within the context of company ranking. This new idea can be successfully applied to solve various types of MADM problems in the banking and finance environment. This paper studies the application of DoE and TOPSIS method together to make company ranking. Therefore, in this study 2^k full factorial DoE and also 2^{k-p} fractional-factorial DoE approaches are used to illustrate how the financial ratios affect TOPSIS scores of a multi attribute company ranking problem. The application steps of the DoE–TOPSIS approach are illustrated in the Fig. 1.

3. Illustrative case study for the DoE–TOPSIS application

The DoE–TOPSIS application (see Fig. 1) consists of the following steps:

Step 1: Determine the relevant financial ratios (attributes) and companies (alternatives).

For the illustrative case study, the financial ratios are determined based on the Ginevičius and Podvezko's [13] study shown in Table 1. Ginevičius and Podvezko's [13] study includes five financial ratios and four alternative companies. Among these five financial ratios, Prompt Liquidity (PL), Critical Liquidity (CL), Overall Liquidity (OL) and Mobility (M) are benefit attributes, whereas Ratio of Debts (RD) is a cost attribute.