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Analysis of the financial parameters of Serbian banks through the application of the fuzzy AHP and TOPSIS methods

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ABSTRACT

Banks represent entities of the financial market and the overall system for financing of the economy, i.e. they are directly or indirectly becoming the drivers and control mechanism of the financial system without which the process of reproduction would be practically impossible. Banks, as specific financial institutions, hold a central place within the financial system due to the functions they perform, as well as the relative volume of financial potential that resides within their accounts. Evaluation of the work of banks is of essential importance to creditors, investors and other interested parties, because it determines a bank's ability to be competitive within the sector. The aim of this study is to propose a fuzzy multi-criteria model that will facilitate the assessment of the financial performance of banks. An analysis was performed of the entire banking sector in Serbia covering the period between the years 2005 and 2010. Methods such as the Fuzzy Analytic Hierarchy Process (FAHP) and the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS) have been integrated into the proposed model. In the first phase, we determined the priority weights of criteria using FAHP, while in the second phase we performed a ranking of the banks through the application of the TOPSIS method.

1. Introduction

In banking, as in many other industries, a business reputation is especially important and has a significant effect on overall financial performance. The biggest threat to any bank, regardless of the scope of its presence on a particular market, is the loss of business reputation. The security of a bank is a basic prerequisite for the obtainment and preservation of its long-term reputation within the public. One of the parameters of a bank's security is its assets, i.e. the assets it has at its disposal. The major role of this parameter is in the performance of business activities and the realization of target performance in terms of profitability, solvency and liquidity.

Since the year 2001, the banking sector in Serbia has undergone major changes in conditions of an intensified process of economic transition. Banks owned by foreign entities account for 74% of the total assets of the Serbian banking sector, and just as much of its capital. At the same time, foreign banks employ 20,564 people, which is 70.6% of the total 29,117 employees working in the banking sector in Serbia.

The Serbian banking sector is heavily dependent on foreign banks, primarily from countries of the European Union which has been for a long time now shaken by the debt crisis which negative consequences are already being felt, whereby any further deepening of the crisis would have even stronger negative effects on the domestic banking sector. The acute problem of the Serbian banking sector is the significant share of non-performing loans, which makes it especially important to possess adequate metrics for the effective management of financial performance (Bulajic et al., 2012). Furthermore, the banking sector in Serbia is characterized by a high level of competition i.e. a low level of concentration bearing in mind the large number of banks with a low participation in the most significant categories of banking operations, such as: assets, loans, deposits, interest income, income from fees and commissions, and similar.

In the financial service sector, especially when it comes to banking activities, there is an increasing need for measuring performance. Due to increased uncertainty and competition in the global banking markets, measuring performance using fuzzy techniques provides clear and reliable information. The main objective of this study is to provide decision-making support, by enabling the decision-makers to measure the effectiveness of banks through the application of multi-criteria decision-making. In this regard, the paper proposes a model for evaluating the banking system's performance, which combines two multi-criteria methods: Fuzzy Analytic Hierarchy Process (FAHP) and the Technique for Order Performance by Similarity to Ideal Solution (TOPSIS). The FAHP method is used to determine the priority weights of the criteria, which are then used as the input weights of the criteria

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for the TOPSIS method, whose application allows for ranking of the banks.

The paper is organized in the following manner: the following section provides a brief review of the literature. Section 3 indicates the basic starting points of fuzzy set theory and extended fuzzy AHP analysis, while Section 4 presents the TOPSIS method. Section 5 presents the integrated fuzzy AHP — TOPSIS model for evaluating the financial parameters of the Serbian banking sector. The paper ends with the concluding remarks which are given in Section 6.

2. Review of the literature

In the literature, many authors have used multi-criteria decision-making methods to evaluate the financial performance of the banking sector. The method that has in numerous studies been recognized as a useful and systematic tool for measuring bank performance is the Analytic Hierarchy Process — AHP (Saaty, 1980). In their study, Ta and Kar (2000) used the AHP approach to make a selection of banks in Singapore. Frei and Harker (1999) applied the AHP approach as an alternative to the DEA method in order to measure bank performance and explore the relationship between financial and operational performance. Yurdakul and Iç (2004) applied the AHP method to investigate the credibility of companies which is necessary in bilateral relationships between production companies and banks in Turkey.

However, the AHP method is often criticized in the literature for failing to take into account risks and uncertainties during the process of evaluation (Chan et al., 2008; Dyer et al., 1992). Although AHP has found wide application for solving multi-criteria decision-making problems in real situations, this approach fails to provide satisfactory results in situations that can be characterized as uncertain. A lot of information cannot be expressed by numbers. Ideally, the information should be precise, certain, exhaustive and unequivocal. But in reality, it is often necessary to use information which does not have those characteristics and hence there is a need to face the uncertainty of a stochastic and/or fuzzy nature (Munda et al., 1995). Furthermore, the criteria are often of a subjective and qualitative nature, which has a negative impact on the decision-maker in terms of expressing his own references in numerical values and the subsequent comparison of the estimates (Chan and Kumar, 2007). This is precisely what has led researchers to propose a fuzzy version of the AHP method, which has been adapted to situations of risks and uncertainty (Bottani and Rizzi, 2005; Chan et al., 2008; Mikhailov, 2002). A fuzzy assessment in the decision making process is very useful for the purpose of compensating for the above mentioned shortcoming of the AHP method.

There are many articles which use fuzzy approach to measure financial parameters in the banking sector. For example, Ishizaka and Nguyen (2013) used fuzzy AHP method to facilitate selection of student bank accounts. Also, Weifeng and Huihuan (2008) used the same method to evaluate the performances of commercial banks. Chen et al. (2013) applied the fuzzy DEA method to analyze banking operations and market risk in Taiwan. Che et al. (2010), on the other hand, was using fuzzy AHP and DEA methods to assist in decision making when it comes to the choice of bank loans for small and medium enterprises in Taiwan.

The authors who have applied similar methods to analyze banks as explored in this paper are: Seçme et al. (2009) measured financial performance of banks operating in Turkey. For this purpose he used fuzzy AHP and TOPSIS methods. The same methods were used by Mahrooz et al. (2013) to evaluate the performance of Iranian banks. Similarly, Akkoç and Vatansever (2013) proposed fuzzy AHP and fuzzy TOPSIS model to analyze Turkish banking sector, after the global financial crisis.

3. Fuzzy set theory

The theory of fuzzy sets was presented by Zadeh (1965) as an effective method for mathematical representation of uncertain and imprecise evaluations made by humans. Human assessments are generally characterized by imprecise language, such as the terms “equal”, “weak”, “fairly strong”, “very strong” and “absolute”. Therefore, the application of the fuzzy theory by decision-makers enables them to successfully deal with uncertainties. Furthermore, fuzzy logic can be the basis for numerous methods through which qualitative assessments can be expressed through quantitative data.

That makes fuzzy set theory a more efficient approach compared to classical (binary) set theory is its ability to reflect the real world (Ertugrul and Tus, 2007). Fuzzy set theory is applicable for the analysis of the same category of issues as classical theory. It is the most suitable technique for synthesis, whenever study findings contain a clear component of linguistic in terms of imprecise measurement (Nijkamp et al., 2008). Fuzzy set theory is based on fuzzy sets which represent a class of objects with a degree of membership (Negoita, 1985). Such sets are characterized by a function of membership which is assigned to each object of the class with a rank that moves within the interval [0,1]. The mathematical operations that are allowed on the sets are: addition, subtraction, multiplication and division (Dubois and Prade, 1987; Kauffmann and Gupta, 1991).

A thorough analysis of fuzzy set theory was given by Zimmermann (1991). Bellman and Zadeh (1970) were the first to introduce the theory of fuzzy sets into the decision-making process, and moreover in situations when vague, imprecise and uncertain data were used to generate a decision. Yager and Basson (1975) had proposed the introduction of fuzzy set theory into solving of the decision-making problem. In addition to the above mentioned authors, others who have dealt with this issue within their work are Zimmermann (1996); Lootsma (1997); Klir and Yuan (1995); and Kahraman et al. (2006).

3.1. Fuzzy AHP method (fuzzy analytic hierarchy process)

The fuzzy AHP method (Fuzzy Analytic Hierarchy Process — FAHP) has been suggested by various authors (Buckley, 1985; Chang, 1996; Mikhailov and Tsvetinov, 2004; Van Laarhoven and Pedrcyz, 1983). FAHP represents a systematic approach to selecting alternatives and solving problems using the concept of fuzzy set theory (Zadeh, 1965) and the AHP method, which are implemented through the use of triangular fuzzy numbers (Chang, 1996). Triangular fuzzy numbers are applied in order to determine the priority of different decision variables, while the extended AHP method is used to determine the final priority of weights based on triangular fuzzy numbers. The most commonly used is the FAHP methodology which was extensively analyzed by Chang (1992, 1996).

Let $X = \{x_1, x_2, \ldots, x_n\}$ be a set of objects, and let $G = \{g_1, g_2, \ldots, g_n\}$ be a set of goals. According to the methodology of extended analysis which was set up by Chang (1992, 1996), an extended analysis of goal gi is performed for every taken object. The values of extended analysis m for each object can be represented as follows:

$$M_{gi}^{1},\ M_{gi}^{2},\ \ldots,\ M_{gi}^{n},\ i = 1, 2, \ldots, n, \tag{1}$$

where $M_{gi}^{j}\ (j = 1, 2, \ldots, m)$ are fuzzy triangular numbers. Chang's extended analysis consists of the following steps:

Step 1. The values of fuzzy extensions for the i-th object are given in Expression (2):

$$S_i = \sum_{j=1}^{m} M_{gi}^{j} \otimes \left[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}\right]^{-1}. \tag{2}$$

In order to obtain the expression $[\sum_{i=1}^{n}\sum_{j=1}^{m} M_{gi}^{j}]^{-1}$, it is necessary to perform additional fuzzy operations with m values of the extended analysis, which is represented by Expressions (3) and (4):

$$\sum_{j=1}^{m} M_{gi}^{j} = \left(\sum_{j=1}^{m} l_i \sum_{j=1}^{m} m_i \sum_{j=1}^{m} u_i\right), \tag{3}$$