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PERFORMANCE EVALUATION MODEL OF ROMANIAN MANUFACTURING LISTED COMPANIES BY FUZZY AHP AND TOPSIS

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Abstract. We are interested in the hierarchy of the main Romanian companies in the manufacturing industry by considering eight financial and seven non-financial indicators. Thirty three listed companies, that are non-financial institutions, were selected for the study and in order to control the reliability of the data we used the Bucharest Stock Exchange database, official data published by the Romanian Ministry of Public Finance, and the annual reports released by the companies on their websites, collecting information for the years 2011–2015. Because the human thinking is subjective and ambiguous we prefer linguistic variables, converted afterwards in triangular fuzzy numbers, to represent the importance of indicators. Our method involves the calculation of the weights of individual or categories of indicators based on Fuzzy Analytic Hierarchy Process. Then, the level of performance for each company, separately for financial, non-financial and all indicators is obtained by TOPSIS method. We deduce an objective hierarchy of the companies on a rigorous basis, which is however dependent from the choice of indicators and the conversion scale of linguistic variables into triangular fuzzy numbers. Also, following the obtained results we concluded that the overall performance of companies for the analyzed period is significantly influenced by non-financial indicators.

Keywords: manufacturing company, indicator, performance, evaluation, fuzzy sets, FAHP, TOPSIS, hierarchy.

JEL Classification: L25, M21, M41, C60, C63.

Introduction

Stock market is a place where stocks, bonds, or other securities are traded according to fixed regulations (Rezaie et al., 2014). In the last decade, the Romanian capital market – a frontier market, but with a possible reclassification as a secondary emerging market in 2018,

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according with FTSE Classification of Markets – has made significant progress. Even if BSE has recorded increasing market capitalization, year by year (Bogdan & Pop, 2008), is still characterized by volatility which shows that efforts need to be further sustained for its development. Several additional requirements of transparency, quality reporting and communication with investors have been imposed since 2015, yet its relatively fast pace, the Romanian capital market remains, in terms of market capitalization, one of the smallest among Central and Easter European markets (B. Dima & S. M. Dima, 2017). The Romanian manufacturing industry is an emerging market, proven by increasing investments from year to year. Out of the total listed companies on BSE we selected those who do business in the manufacturing industry relying on the assumption that companies that activate in IT and manufacturing industry are more likely to disclose information about intangible assets and corporate value (Bogdan et al., 2011). Measuring the performance of Romanian manufacturing companies is of particular interest to investors, shareholders and creditors and in this respect we have analyzed the content of annual reports of sampled companies. Annual reports are the main annual source of communication between the company and its external investors through these means the company publishes investment related information (Bogdan & Pop, 2008).

The companies' performance indicators used in this paper were divided into two categories: financial and non-financial indicators. We considered that nowadays measuring the performance of entities and pursuing their ranking by performance is a complex approach that cannot be limited to selecting and analyzing only financial indicators even if they are considered to be significant in the overall performance assessment. Thevaranjan et al. (1999) observed, it is not always sufficient to create policies and strategic plans by taking only financial criteria as a basis. Starting from studies conducted by Secme et al. (2009), Yalcin et al. (2012) and Hategan and Curea-Pitorac (2017), the financial indicators were also divided into two categories: accounting based indicators or classical financial ratios and value based indicators or modern ratios. Selection of non-financial indicators has been carried out from an expanded perspective, so that besides personnel variables, which are found in the studies we analyzed (Hategan & Curea-Pitorac, 2017; Thevaranjan et al., 1999; Institute of Management & Administration [IOMA], 2002) information on research, development, innovation, environment, CSR, ethics issues and organizational empathy were also included.

In this study the performance evaluation proposed model is twofold: firstly, fuzzy AHP (FAHP) is used for determining the weights of the criteria and secondly, TOPSIS method is used for determining the ranking of the selected companies. Over time AHP has become one of the most widely used multiple criteria decision making methods (see, e.g., Lee et al., 2008; Aydogan, 2011; Calabrese et al., 2013; Amile et al., 2013; Yurdakul, 2004; Xia & Wu, 2007; Chan & Kumar, 2007). The method takes into consideration the judgments of decision makers to obtain the importance of each criterion with respect to all other criteria as a pairwise comparison matrix. Then, the weights of the criteria are obtained in few steps by quite simple calculations. The Fuzzy Set Theory makes the entire process more flexible (see Kahraman et al., 2003), therefore a fuzzy AHP (FAHP) method was carried out (Van Laarhoven & Pedrycz, 1983; Chang, 1996; Amile et al., 2013). The already classical TOPSIS method assumes the ranking of alternatives in multicriteria decision making prob-

lems by measuring the distances from each alternative taken into consideration to a hypothetical positive ideal alternative and a hypothetical negative ideal alternative (see e.g. Hwang & Yoon, 1981; Yalcin et al., 2012). Often, FAHP and TOPSIS are used together in assessing the financial, non-financial or global performance of companies: Yalcin et al. (2012), in order to rank the companies of each sector in the Turkish manufacturing industry; Aydogan (2011), in the performance measurement of the Turkish aviation companies; Choudhary and Shankar (2012), in the selection of the thermal power plant; Ertugrul and Karakasoglu (2009), in the ranking of the fifteen Turkish selected listed companies; Kluczek and Gladysz (2015), in the exploring of the main possibilities for environmental improvements in the painting process of the manufacture of central heating boilers; Moghimi et al. (2013), in the evaluation of Iranian cement producing companies; Secme et al. (2009), in the ranking of largest five Turkish commercial banks from a financial and nonfinancial perspective; Sun (2010), for the selection of the global top four notebook computer companies; Buyukozkan and Cifci (2012), in the determination of key components of an electronic service quality concept; Gumus (2009), in order to evaluate hazardous waste transport companies; Mandic et al. (2014), to facilitate the assessment of the Serbian banks, etc..

The main result of our study is a ranking of the manufacturing companies by considering their total performance based on all financial and non-financial indicators. Nevertheless, the separate hierarchies on financial indicators and non-financial indicators offer us interesting conclusions on the companies and on the Romanian manufacturing industry as a whole. The reminder of this paper is organized as follows. In Section 1 we present the selected financial and non-financial indicators and in Section 2 we discuss the triangular fuzzy numbers. Then, in Section 3 we reveal the methodology used: FAHP method and TOPSIS method. We calculate the weights of indicators by FAHP in Section 4. The way of collecting data and their primary processing are included in Section 5. Next section presents the results of ranking of the companies based on the TOPSIS method, along with some related discussions. In the end of our work some conclusions and limits of the study are given.

1. Measuring companies' performance by financial and nonfinancial indicators

In the economic field, in general, performance is the achievement of organizational goals, as an amount of everything that contributes to achieving strategic goals, and over time, evaluating companies' performance has been a widely debated issue in trying to find the best measuring instrument. The last decades showed that indicators used in measuring performance are diverse, financial ones are complemented by non-financial indicators and measurement methods are increasingly diversified in search of the most relevant model (Singh & Vinodh, 2017; Sahu et al., 2017; Yaghoobi & Haddadi, 2016; Dahooie et al., 2019; Fenyves et al., 2018; Kiselakova et al., 2018; Tripathi et al., 2019). Measuring entity performance is one of the most effective ways to find the status of each company or entity (Amile et al., 2013). In the present paper, we apply a performance measurement model for the Romanian companies listed in the manufacturing industry.

1.1. Financial indicators

Financial indicators are the most used indicators in measuring an entity's performance. Taking into account the particularities of the Romanian capital market and the frequency of using the indicators in order to measure the performance of the Romanian companies in the manufacturing industry, we have selected in our study some relevant indicators for measuring the financial performance. We have classified them in classical, traditional indicators and modern indicators of value creation.

***Traditional indicators* (*accounting based indicators*)**

a) Return on assets (ROA) relates to a company's after tax net income during a specific fiscal year to the company's average total assets during the same year (Yalcin et al., 2012; Callan & Thomas, 2009; Erhemjamts et al., 2013; Garcia-Castro et al., 2010; Nelling & Webb, 2009; Pirtea et al., 2014). As Palepu et al. (2000) noted, ROA shows how much profit a company is able to generate for the money invested in assets. Yalcin et al. (2012), highlighted that because ROA determines how effectively a company has used the total assets at its disposal to generate earnings it has a great importance for manufacturing industries. For ROA calculation we used the formula:

$$\text{ROA} = \frac{\text{Net income available to common stockholders}}{\text{Total assets}} \cdot 100. \quad (1)$$

b) Return on equity (ROE) measures the rate of return on the ownership interest of the common stock owners (Callan & Thomas, 2009; Garcia-Castro et al., 2010; Mahoney & Roberts, 2007; Makni et al., 2009). It measures a company's efficiency at generating profit from net assets and shows how well a company uses the invested money to generate earnings growth (Ertugrul & Karakasoglu, 2009). For ROE calculation we used the formula:

$$\text{ROE} = \frac{\text{Net income}}{\text{Shareholders equity}} \cdot 100. \quad (2)$$

c) Earnings per share (EPS) is the indicator of each outstanding share of a company (Shaverdi et al., 2014) disclosing the company's strength. EPS is calculated by dividing the company's net income available to shareholders by the number of shares outstanding during the same period and allows comparison of different company's power to make money (Yalcin et al., 2012). According to Jordan et al. (2007), it is a significant measure because the market reacts to a company's ability to meet its earnings expectations. For EPS calculation we used:

$$\text{EPS} = \frac{\text{Net income available to shareholders}}{\text{Number of shares outstanding}}. \quad (3)$$

d) Solvability (SOL) shows to what extent the entity's total assets (AT) can cover total debts (DT). Practically, financial solvency is the ability of asset items to honor the entity's debts irrespective of their maturity order. The general conceptual framework of IFRS (International Accounting Standards Board [IASB], 2011), considered that financial solvency refers to the willingness to use cash for a longer period of time in which to honor the financial commitments as they become due. SOL was calculated as follows:

$$\text{SOL} = \frac{\text{Total assets}}{\text{Total liabilities}} \cdot 100. \tag{4}$$

Value added indicators

a) Economic value added (EVA) is a model of performance measurement of the entity designed by Stewart (1991) and represents practically, the operational profit from which the opportunity cost of the entire invested capital is deducted, representing the measure of the real economic profit obtained by the enterprise. EVA is not just a simple measure of performance but can be adopted to decentralize the management decision (Cabinova et al., 2018). The EVA calculation relationship proposed by Stewart (1991) is: EVA = Net operating profit after taxes – Cost of invested capital. Several ways of representing the EVA indicator are known in performance measurement. In this study we used the following EVA calculation method:

$$\text{EVA} = \text{Invested capital} \cdot \left(\text{ROCE-WACC}\right), \tag{5}$$

where: ROCE = return on capital employed, and WACC = weighted average cost of capital.

b) Market value added (MVA) measures the difference between the market value of a company and the total invested capital; as a consequence, if MVA is positive, the company added value, otherwise, if MVA is negative, the company destroys value (Ciora, 2013). The MVA calculation in the present study was performed after the relationship:

$$\text{MVA} = \text{MV} - \text{TIC}, \tag{6}$$

where: MV = market value, and TIC = total invested capital, composed of the present value of the initial capital invested by the shareholders and the present value of the reinvested profits.

c) Cash flow return on investment (CFROI) is a complex and comprehensive rating indicator of a company performance, created and developed by Madded (1999), driven by the need for high performance and the pressure of corporate management to implement value management systems. CFROI is an indicator that is calculated by complex means, it is difficult to use by non-financial managers, and in terms of calculation and adjustment methods it is similar to EVA indicator. In this study we used the calculation method of CFROI proposed by Martin and Petty (2000), the one-time approach:

$$\text{CFROI} = \frac{\text{GCF-D}}{\text{GI}} \cdot 100, \tag{7}$$

where: GCF = gross cash flow; D = depreciation of fixed assets; GI = gross investments.

d) Cash value added (CVA) is an indicator built on cash flow theory but exceeds CAPM's capital cost imperfections (Martin & Petty, 2000). According to Ciora (2013), the determination of the indicator starts from the company's gross cash flow during the period (GCF) and the depreciation of fixed assets (D) as well as the cost of the total capital used for financing the activity (CTC) is deducted: CVA = GCF – D – CTC. Another way of presenting the CVA is the ratio to the rate of return on cash flows (CFROI) used by us in building up this study. In this study we used the following calculation:

$$CVA = GI \cdot (CFROI\text{-}WACC), \tag{8}$$

where: GI = value of gross investments; CFROI = cash flow return on investment; WACC = weighted average cost of capital.

1.2. Nonfinancial indicators

More recent works in measuring the overall or total performance of companies' demonstrates the importance and necessity of using non-financial indicators to assess the entity's competitiveness and efficiency. Ittner et al. (1997), noted that non-financial performance criteria show up as an emerging asset especially in performance measurement. According to Secme et al. (2009), in general terms, non-financial performance criteria are defined as the criteria which cannot be physically measured. As we found in IOMA's Report (IOMA, 2001, 2002), these measures can be categorized as follows: customer satisfaction, number of newly added customers, market share, productivity, quality-process relation, personnel turnover, quality and flexibility, innovation and process of developing new products, supply resources and demographic features. Yuksel and Dagdeviren (2010), integrated BSC (Balanced Scorecard) approach, which is a method of determining business performance using indicators on the basis of vision and strategies, with fuzzy ANP technique to determine the performance level of a business in the manufacturing industry. Botezat et al. (2018) showed that in the case of Romanian producers, the practices related to "green purchasing" and "customer cooperation" significantly determine the level of companies' performance. Hategan and Curea-Pitorac (2017), used as non-financial indicators the number of employees, the listed period and the ownership structure of the companies (private or state owed). Secme et al. (2009), used five non-financial criteria in their study, considered usually accepted criteria in the literature: pricing, differentiation, marketing, service delivery and productivity. The selection of the non-financial indicators included in our study was made taking into account the mandatory and voluntary reporting practices of the Romanian companies listed on the BSE, as well as the international reporting and financial communication requirements. In their selection, the nature of the industry was also a criterion. Thus, the non-financial indicators included in this study are:

a) Creativity, Design and Innovation (CRTV), a selected indicator due to the nature of the industry for which the degree of disclosure of innovation and creativity was pursued in the annual reports of the companies included in the sample.
b) Personnel or Employee Variables (PERS), for which were followed the disclosure of employee information (age, education, training, benefits, bonuses, incentives, disclosure of employees performance, distributions by gender, etc.), data being collected from the annual reports of selected companies.
c) Environmental indicator (MED) regarding information disclosed about carbon dioxide, greenhouse gas and other environmental issues reported by sampled companies, due to the growing international green reporting practices.
d) Corporate Social Responsibility (CSR) variables, for which we aimed to identify information disclosed by selected companies about engagements or programs and social projects involved and voluntary support offered to the social community in various aspects with social implications.

e) Ethics, Integrity and Deontology (ETIC), an indicator for identifying disclosures about the existence of a code of ethics, integrity and deontology of the company, or elements contained in such a code in the annual reports of selected entities. The indicator has been selected due to growing international reporting and communication practices on ethical behavior.

f) Artificial Intelligence (ARTQ), an indicator for identifying information disclosed in the annual reports of selected companies about various software used in the company's activity, software creation, and other existing IT assets.

g) Organizational Empathy (EMPTH) introduced by us as a result of the growing importance of the psychological studies conducted on the reporting and financial communication practices, which followed to identify the information disclosed by entities regarding the degree of cohesion among employees, the social interaction between them, the exchange ideas, support in achieving new performances, and disclosure of events organized by companies in order to increase the degree of employee interaction. The choice of the indicator is based on the idea of Binder (2016), regarding the analysis of performance of organizational work results that may improve the organization's ability to set expectations, more realistically, and also to establish conditions for optimizing organizational performance based on cultural values.

As opposed to other works related to performance evaluation of manufacturing industry, based on a metafrontier approach (see, Chiu et al., 2018) we followed a fuzzy AHP method combined with TOPSIS, taken into account the aim of the study to establish a relevant hierarchy of the selected companies depending on the proposed indicators.

2. Triangular fuzzy numbers

People cannot precisely express their preferences because of the complexity and vagueness of decision making problems (Li et al., 2017). In this regard was introduced the fuzzy set theory by Zadeh (1965), which is suitable for subjective judgment and qualitative assessment in the evaluation processes of decision making, oriented to the rationality of uncertainty due to vagueness. A fuzzy set A on a universe X can be represented by a membership function defined on X with a continuum of grades of membership ranking between 0 and 1 (Zadeh, 1965). If the assigned value to x in X is 0, then the element does not belong to A, if the value assigned x in X is 1 then the element belongs complete to the set A and if the value lies between 0 and 1 then the element x in X belongs to the fuzzy set A only partially (Li et al., 2017; Secme et al., 2009; Yalcin et al., 2012; Ertugrul & Karakasoglu, 2009; Lima et al., 2014; Mahdavi et al., 2008; Moghimi et al., 2013; Sun, 2010; Ecer, 2018; and others).

Due to their simplicity, the triangular and trapezoidal fuzzy numbers are the most common used fuzzy numbers in practice, preferred for representing the linguistic variables. A triangular fuzzy number is a fuzzy set on $\mathbb{R}$ (the set of real numbers) given by the membership function μ, where $\mu(x)=0$ if $x < l$ or $x > u$, $\mu(x)=(x-l)/(m-l)$ if $l \le x \le m$ and $\mu(x)=(u-x)/(u-m)$ if $m \le x \le u$. If $l = m$ and/or $m = u$ then the membership function μ is adapted in an obvious way. As Li et al. (2017) pointed out, a triangular fuzzy number (TFN) is represented with three points: $M=(l, m, u)$, where the parameters l, m, u indicate

the smallest possible value, the most promising value and the largest possible value that describe a fuzzy quantity. The addition of two triangular fuzzy numbers (l_1, m_1, u_1) and (l_2, m_2, u_2) is defined as (l_1, m_1, u_1) + (l_2, m_2, u_2) = ($l_1 + l_2$, $m_1 + m_2$, $u_1 + u_2$). The reciprocal of a positive triangular fuzzy number (l, m, u) is given by $(1/u, 1/m, 1/l)$ (see Yalcin et al., 2012, for example).

There are several methods to convert fuzzy numbers into crisp real numbers. The expected value is between the most common approaches (see Heilpern, 1992; Ban & Coroianu, 2015). For a triangular fuzzy number (l, m, u), the expected value is $\frac{l+2m+u}{4}$.

In the present study, TFNs are used to represent the linguistic variables corresponding to the importance of different criteria, according with the conversion scale given in Table 1. The reciprocal TFNs are given in Table 1, too.

Table 1. Linguistic variables expressed by triangular fuzzy numbers

Linguistic variables	Triangular fuzzy number	Reciprocal triangular fuzzy number
Extremely important	(1.4, 2, 2.5)	(0.40, 0.50, 0.71)
Very important	(1.2, 1.8, 2.2)	(0.45, 0.55, 0.83)
Important	(1, 1.5, 1.8)	(0.55, 0.67, 1)
Moderately important	(0.8, 1.2, 1.6)	(0.62, 0.83, 1.25)
Equally important	(1, 1, 1)	(1, 1, 1)

3. FAHP and TOPSIS methods

There are several multi-criteria decision making methods – crisp, fuzzy, stochastic or combination of them – elaborated and/or applied in the literature (see, e.g., Ban, 2011; A. I. Ban & O. Ban, 2012; Chang, 1996; Chan & Yeh, 2001; Deng, 1999; Hwang & Yoon, 1981; Saaty, 1980, 1992, 2008; Yalcin et al., 2012; Zeleny, 1982; Zolfani & Šaparauskas, 2013; Ignatius et al., 2016; Shaverdi et al., 2016; Erdogan et al., 2017; Samanlioglu et al., 2018). The choice of a technique used in a multicriteria decision making problem is rather arbitrary, because each technique has its own advantages and disadvantages and it does not exist a method to find the most appropriate (see Zavadskas & Turkis, 2011). In the present paper we choose to calculate the weights of performance indicators by applying FAHP method and to hierarchize the considered companies on the basis of TOPSIS method.

3.1. FAHP algorithm for determining the weights of indicators

The Analytic Hierarchy Process (AHP)–proposed by Saaty (1980) is a method of measurement through pairwise comparisons. It is often used in multi-attribute decision making problems (see e.g. Saaty, 2008) to calculate the weights of indicators based on a pairwise comparison matrix with positive elements $a_{ij}, i, j \in \{1,...,n\}$ such that $a_{ii} = 1$ for every $i \in \{1,...,n\}$. Usually, a such matrix is reciprocal, that is $a_{ij} = \frac{1}{a_{ji}}$, for each $i, j \in \{1,...,n\}$. We say that a pairwise comparison matrix is consistent if $a_{ij}\, a_{jk} = a_{ik}$ for each $i, j, k \in \{1,...,n\}$. The incon-

sistency of pairwise comparison matrices is measured by consistency indices (see the survey Kou et al., 2016). Due to its simplicity, the consistency index *CI* defined as $CI = \frac{\lambda_{\max} - n}{n-1}$, where $\lambda_{\max}$ is the principle eigenvalue of the matrix $\left(a_{ij}\right)_{i,j\in\{1,...,n\}}$ is preferred (see Ramik & Korviny, 2010; Saaty, 1991; Bernasconi et al., 2010). Generally, if $CI < 0.1$ then the matrix is quite consistent to be used in the computation of weights (see Leung & Cao, 2000).

The analytic hierarchy process is often criticized due its inability to handle the uncertainty and imprecision which appear in solving multi-criteria analysis problems. The fuzzy approach overcomes this weakness and makes the entire process more flexible, keeping its accuracy.

The Chang's extent FAHP method (Chang, 1996) is the most frequently used algorithm in the present topic, although it is sometimes criticized (see Ahmed & Kilic, 2015, 2019; Wang et al., 2008; Zhu et al., 1999). As in Yalcin et al. (2012), we use the Chang's method to calculate the weights of indicators in a set $\{C_1,...,C_n\}$ starting from a consistent fuzzy pairwise comparison matrix $M = (M_i^j)_{i,j\in\{1,...,n\}}$. Some consistency measures for pairwise comparison matrices with fuzzy elements were investigated in some papers (see, e.g., Buckley et al. 2001; Ramik & Korviny, 2010). They are very complicated and, in addition, they have not been tested so well in practice. We prefer to change a fuzzy pairwise comparison matrix into a crisp matrix (by defuzzifying with the expected value, for example) whose consistency index *CI*, defined as above, is computed to conclude the consistency or inconsistency (see Secme et al., 2009).

The triangular fuzzy number $M_i^j = (l_i^j, m_i^j, u_i^j)$ is situated on line *i* and column *j* in *M* and it signifies the importance of the indicator *i* with respect to the indicator *j*. It is natural to consider $M_i^i = (1,1,1)$ for every $i \in \{1,...,n\}$. Usually (see e.g. Yalcin et al., 2012 or Deng, 1999), $M_i^j = (l_i^j, m_i^j, u_i^j)$ with $i < j$ are given and M_i^j with $i > j$ are considered as reciprocal fuzzy numbers, that is $M_i^j = \left(\frac{1}{u_i^j}, \frac{1}{m_i^j}, \frac{1}{l_i^j}\right)$, for every $i, j \in \{1,...,n\}$, $i > j$. Under the above notations, the following algorithm can be applied:

Algorithm 1. Let $M_i^j = (l_i^j, m_i^j, u_i^j)$, $i \in \{1,...,n\}$, $j \in \{1,...,n\}$ the fuzzy pairwise comparison matrix of a set of criteria, $\{C_1,...,C_n\}$.

Step 1: For $i \in \{1,...,n\}$ compute

$$S_i = \left(l_i, m_i, u_i\right) = \left(\frac{\sum_{j=1}^n l_i^j}{\sum_{i=1}^n \sum_{j=1}^n u_i^j}, \frac{\sum_{j=1}^n m_i^j}{\sum_{i=1}^n \sum_{j=1}^n m_i^j}, \frac{\sum_{j=1}^n u_i^j}{\sum_{i=1}^n \sum_{j=1}^n l_i^j}\right). \tag{9}$$

Step 2: For $l, k \in \{1,...,n\}$ compute

$$v_{lk} = \begin{cases} 1, & \text{if} \quad m_l \geq m_k \\ 0, & \text{if} \quad l_k \geq u_l \\ \frac{l_k - u_l}{\left(m_l - u_l\right) - \left(m_k - l_k\right)}, & \text{otherwise} \end{cases}. \tag{10}$$

Step 3: For $i \in \{1,...,n\}$ compute

$$d_i' = \min\{v_{i1},...,v_{i,i-1},v_{i,i+1},...,v_{in}\}. \quad (11)$$

Step 4: For $i \in \{1,...,n\}$ compute

$$d_i = \frac{d_i'}{\sum_{i=1}^{n} d_i'} \quad (12)$$

the weight of the indicator $C_i, i \in \{1,...,n\}$.

3.2. TOPSIS algorithm for determining the ordering of a set of companies

In the present paper the weights of the indicators are crisp numbers obtained by the Chang's extent FAHP method. The performance of a company with respect to an indicator is a crisp number too, obtained from official sources: Bucharest Stock Exchange database, the annual reports released by the companies on their websites and published by the Romanian Ministry of Public Finance. We conclude that a crisp method is suitable to be applied for determining the ordering of the companies with respect to their performance. Between the methods of ranking of the alternatives in multi-criteria decision making problems, the classical TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) and VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje) are preferred for their simplicity.

In brief, TOPSIS (see Hwang & Yoon, 1981) assumes the representation of alternatives which must be evaluated as points in a finite dimensional space. Then, a positive ideal alternative and a negative ideal alternative are determined in the same space. The place of an alternative is better in the final hierarchy if it is close to the positive ideal alternative and far to the negative ideal alternative. The corresponding algorithm is given below. Let $\{A_1,...,A_J\}$ be a set of companies which must be ordered with respect to their performance on n indicators, $\{C_1,...,C_n\}$, the weight of every indicator being known.

Algorithm 2. Let $w_{ji}, i \in \{1,...,n\}, j \in \{1,...,J\}$ the performance of the company j under the indicator i. Let $d_i, i \in \{1,...,n\}$ the normalized weight of the indicator i.

Step 1: For $i \in \{1,...,n\}, j \in \{1,...,J\}$ compute

$$r_{ji} = \frac{w_{ji}}{\sqrt{\sum_{j=1}^{J} w_{ji}^2}}. \quad (13)$$

Step 2: For $i \in \{1,...,n\}, j \in \{1,...,J\}$ compute

$$V_{ji} = d_i r_{ji}. \quad (14)$$

Step 3: For $i \in \{1,...,n\}$ compute

$$V_i^+ = \max\{V_{1i},...,V_{Ji}\} \quad (15)$$

and

$$V_i^- = \min\{V_{1i},...,V_{Ji}\}. \quad (16)$$

Step 4: For $j \in \{1,...,J\}$ compute

$$d_j^+ = \sqrt{\sum_{i=1}^{n} (V_{ji} - V_i^+)^2} \quad (17)$$

and

$$d_j^- = \sqrt{\sum_{i=1}^{n}\left(V_{ji} - V_i^-\right)^2}. \tag{18}$$

Step 5: For $j \in \{1,...,J\}$ compute

$$D_j = \frac{d_j^-}{d_j^- + d_j^+}. \tag{19}$$

The decreasing ordering of the values $D_j, j \in \{1,...,J\}$ give us the decreasing ordering of the companies $A_1,...,A_J$.

4. Weights of indicators by FAHP

4.1. Weights of value added indicators

As we already mentioned in Section 1.1., EVA, MVA, CFROI and CVA are considered as value added indicators in our study. The fuzzy pairwise comparison matrix of these criteria is given in Table 2 taking into account the conversion scale in Table 1. As example, the significance of the first line in Table 2 means that EVA is important with respect to MVA and CFROI and extremely important with respect to CVA. As usually (see e.g. Yalcin et al., 2012), the elements below the diagonal are the reciprocal triangular fuzzy numbers of their symmetrical. Going to the crisp pairwise comparison matrix by the expected value, we obtain $CI = 0.0268 < 0.1$, that is we can consider that the matrix given in Table 2 is consistent. Based on the data in Table 2, we apply Algorithm 1 to calculate the weights of the value added indicators. According to the FAHP method the most important value based financial indicators are EVA (0.390) and MVA (0.311), followed by CFROI (0.212) and CVA (0.087). We can consider the value based financial performance as a composite indicator of the formula 0.390·EVA + 0.311·MVA + 0.212·CFROI + 0.087·CVA.

Table 2. Fuzzy pair-wise comparison matrix for the sub-criteria of the VFP (value based financial performance) main-criteria

Indicators	EVA	MVA	CFROI	CVA
EVA	(1, 1, 1)	(1, 1.5, 1.8)	(1, 1.5, 1.8)	(1.4, 2, 2.5)
MVA	(0.55, 0.67, 1)	(1, 1, 1)	(1, 1.5, 1.8)	(1.2, 1.8, 2.2)
CFROI	(0.55, 0.67, 1)	(0.55, 0.67, 1)	(1, 1, 1)	(1, 1.5, 1.8)
CVA	(0.40, 0.50, 0.71)	(0.45, 0.55, 0.83)	(0.55, 0.67, 1)	(1, 1, 1)

4.2. Weights of accounting based indicators

The fuzzy pairwise comparison matrix of the accounting based indicators ROA, ROE, EPS, and SOL, as they were introduced in Section 1.1., is given in Table 3. As we can see from the first line in Table 3, ROA is moderately important with respect to ROE, important with respect to EPS, and very important with respect to SOL. On the other hand, the matrix given in Table 3 is consistent because the corresponding crisp matrix has $CI = 0.0291 < 0.1$. We apply again Algorithm 1 to obtain the weights of these indicators. FAHP method revealed that

Table 3. Fuzzy pair-wise comparison matrix for the sub-criteria of the AFP (accounting based financial performance) main-criteria

Indicator	ROA	ROE	EPS	SOL
ROA	(1, 1, 1)	(0.8, 1.2, 1.6)	(1, 1.5, 1.8)	(1.2, 1.8, 2.2)
ROE	(0.62, 0.83, 1.25)	(1, 1, 1)	(1, 1.5, 1.8)	(1.2, 1.8, 2.2)
EPS	(0.55, 0.67, 1)	(0.55, 0.67, 1)	(1, 1, 1)	(1.2, 1.8, 2.2)
SOL	(0.45, 0.55, 0.83)	(0.45, 0.55, 0.83)	(0.45, 0.55, 0.83)	(1, 1, 1)

the most important accounting based financial indicators are ROA (0.338) and ROE (0.314), followed by EPS (0.243) and SOL (0.105). Thus, we can look at accounting based financial performance as a composite indicator 0.338·ROA + 0.314·ROE + 0.243·EPS + 0.105·SOL.

4.3. Weights of non-financial indicators

Seven non-financial indicators, described in Section 1.2., were selected for our study: CRTV, PERS, MED, CSR, ETIC, ARTQ, EMPTH. It is not so easy to establish an ordering between each pair of these indicators, but, in the present study, we consider the pairwise comparison matrix given in Table 4. As usually, the triangular fuzzy number from the line i and column j, $i \leq j$, indicate the importance of the indicator i with respect to the indicator j, by considering the conversion scale in Table 1. As it can be seen in Table 4, creativity, design and innovation is extremely important with respect to personnel variables and artificial intelligence, important with respect to environmental variables, corporate and social responsibility indicator and organizational empathy variables, but moderately important with respect to organizational ethical behaviour. We calculate the consistency index of the crisp matrix obtained after defuzzifying with the expected value from the fuzzy pairwise comparison matrix given in Table 4. We obtain $CI = 0.0559 < 0.1$, therefore it can be considered as consistent. By applying again Algorithm 1, based on the data in Table 4, we obtain the weights of non-financial indicators in a normalized form. According to FAHP method, the most important non-financial indicators are CRTV (0.207), PERS (0.205) and MED (0.166), representing variables assigned to information disclosed by the companies in regard with creativity, design, research, innovation practices, followed by variables that concerned personnel and information regarding environmental issues. The normalized weights obtained for CSR are 0.136 and for

Table 4. Fuzzy pair-wise comparison matrix for the sub-criteria of the non-FP main-criteria

Indicators	CRTV	PERS	MED	CSR	ETIC	ARTFQ	EMPTH
CRTV	(1, 1, 1)	(1.4, 2, 2.5)	(1, 1.5, 1.8)	(1, 1.5, 1.8)	(0.8, 1.2, 1.6)	(1.4, 2, 2.5)	(1, 1.5, 1.8)
PERS	(0.40,0.50,0.71)	(1, 1, 1)	(1, 1.5, 1.8)	(1.4, 2, 2.5)	(1.2, 1.8, 2.2)	(1.2, 1.8, 2.2)	(1.4, 2, 2.5)
MED	(0.55,0.67, 1)	(0.55, 0.67, 1)	(1, 1, 1)	(1, 1.5, 1.8)	(1.2, 1.8, 2.2)	(1.2, 1.8, 2.2)	(0.8, 1.2, 1.6)
CSR	(0.55,0.67, 1)	(0.40,0.50,0.71)	(0.55, 0.67, 1)	(1, 1, 1)	(1.2, 1.8, 2.2)	(0.8, 1.2, 1.6)	(1, 1.5, 1.8)
ETIC	(0.62,0.83,1.25)	(0.45,0.55,0.83)	(0.45,0.55,0.83)	(0.45,0.55,0.83)	(1, 1, 1)	(0.8, 1.2, 1.6)	(1.2, 1.8, 2.2)
ARTFQ	(0.40,0.50,0.71)	(0.45,0.55,0.83)	(0.45,0.55,0.83)	(0.62,0.83,1.25)	(0.62, 0.83, 1.25)	(1, 1, 1)	(0.8, 1.2, 1.6)
EMPTH	(0.55,0.67, 1)	(0.40,0.50,0.71)	(0.62,0.83,1.25)	(0.55, 0.67, 1)	(0.45, 0.55, 0.83)	(0.62, 0.83, 1.25)	(1, 1, 1)

ETIC, 0.117. FAHP also revealed that, the least important non-financial indicators are ARTQ (0.090) and EMPTH (0.079), which means that variables assigned to information disclosed in regard to issues concerning artificial intelligence tools used by companies and organizational empathy aspects are very little relevant to the Romanian manufacturing industry. Moreover, within the framework set out in this article we can consider a composite of the non-financial performance as 0.207·CRTV + 0.205·PERS + 0.166·MED + 0.136·CSR + 0.117·ETIC + 0.090·ARTFQ + 0.079·EMPTH.

4.4. Weights of categories of indicators

The value added financial indicators are usually considered as moderately important with respect to accounting based indicators, thus the corresponding fuzzy pairwise comparison matrix could be given as in Table 5. It is a consistent matrix because we obtain $CI = 0.0291 < 0.1$ for the corresponding crisp matrix.

The application of Algorithm 1 leads to the weight of value added indicators and of accounting based indicators equal to 0.569 and 0.431, respectively. According with this result, the financial performance can be aggregated into a composite indicator of value based financial performance and accounting based financial performance as 0.569·VFP + 0.431·AFP.

It is obvious that the financial indicators are more important than the non-financial indicators, consequently, we can consider the fuzzy pairwise comparison matrix in Table 6. The matrix can be considered as consistent because, passing to the crisp matrix by the expected value, we get $CI = 0.0235 < 0.1$.

We apply Algorithm 1 to calculate the weights of the indicators and we obtained for financial indicators the weight 0.702 and for non-financial indicators, 0.298. That is the global performance can be looked as a composite indicator of financial and non-financial performance as 0.702·FP + 0.298·nonFP.

Financial performance and non-financial performance indicators have different level of significance for different users (Ertugrul & Karakasoglu, 2009) and different groups of stakeholders with varying objectives and expectations, obviously approach financial and non-financial analysis from different perspectives (Moyer et al., 1992). As Sekreter et al. (2004) highlighted, managers are especially interested in growth indicators while investors and shareholders focus on profitability ratios, creditors being concerned with financial leverage

Table 5. Fuzzy pair-wise comparison matrix for the main-criteria VFP and AFP

Indicator	VFP	AFP
VFP	(1, 1, 1)	(0.8, 1.2, 1.6)
AFP	(0.62, 0.83, 1.25)	(1, 1, 1)

Table 6. Fuzzy pair-wise comparison matrix for the main-criteria FP, non-FP

Indicator	FP	Non-FP
FP	(1, 1, 1)	(1, 1.5, 1.8)
non FP	(0.55, 0.67, 1)	(1, 1, 1)

ratios. We can add that as to the non-financial indicators, managers will be more interested in design, research, innovation, personnel and environmental indicators while, for instance, investors are interested in CSR variables more than creditors or even managers, or shareholders may be more interested in corporate ethical behavior than managers or creditors. We conclude that, according to FAHP, the most important financial performance indicator for Romanian manufacturing industry is a value based indicator, EVA, and the most important non-financial performance indicator is creativity, design and innovation, CRTV.

5. Sample and data collection

In order to evaluate the performance of Romanian manufacturing listed companies we have selected 33 companies, listed on the BSE, that are non-financial institutions. The data for the determination of the selected financial indicators were manually collected from the financial statements of the Romanian manufacturing companies and from the BSE public database. Most of the information was collected from the balance sheet, the profit and loss account and the explanatory notes of the selected companies. Non-financial information was identified and collected from the annual reports. As Bassemir and Novotny-Farkas (2018) found, all German IFRS private companies disclose significantly more information in their financial reports and also show a higher propensity to publish information voluntarily on their websites. Thus, we considered that IFRS Romanian private companies have similar behavior regarding disclosure of information on their websites. Accordingly, companies' annual reports have been downloaded from official company websites while consulting the official BSE website for additional information.

The selected financial indicators were calculated manually after collecting the information necessary to determine them, using the calculation formulas presented in sections 1.1. For non-financial variables the scoring technique was used for measuring the degree of disclosure. Thus, the scores chosen for non-financial information disclosed in the company's annual reports are: 2-for detailed information disclosed regarding the indicator; 1.5-for non-detailed information disclosed regarding the indicator; 1-for existing but poorly disclosed information regarding the indicator and 0, where there is no disclosed information regarding the indicator. To determine the average degree of disclosure of non-financial information, we used the formula:

$$D_i NFP = \frac{\sum_{i=1}^{n} x_i}{n}, \tag{20}$$

where x_i indicates the scores granted for the non-financial information recognized in the annual reports according to their degree of detail and n indicates the number of selected non-financial variables (7 indicators). The closer the average degree of disclosure is to 2, the higher the volume of non-financial information, communicated in relation to the 7 selected indicators.

Financial and non-financial indicators were calculated and evaluated for the financial years 2011, 2012, 2013, 2014 and 2015. In the absence of the necessary information to determine the indicators from the sample of listed companies, the following were eliminated: Boromir, Electromagnetica, Electroaparataj, Romcarbon, Sinteza and Vrancart. Following Hategan and Curea-Pitorac (2017), to reduce the risk of biases and control the reliability

of the data, we validated the value of the financial indicators from three different sources: the BSE database, official data published by the Romanian Ministry of Public Finance, and the reports released by the companies on their websites. Starting from 1 January 2012, the Romanian companies listed on the BSE have moved to an International Financial Reporting Standards based accounting, so we can consider, as Hategan and Curea-Pitorac (2017) highlighted, this moment as a turning point in the Romanian financial reporting practice. For these reasons we considered that financial years from 2011 to 2015 are relevant for the study. In Table 7, we present the selected companies for which the financial and non-financial indicators have been determined.

Table 7. Selected Romanian manufacturing listed companies

No.	Company	BSE Code
1.	AEROSTAR S.A.	ARS
2.	ALBALACT S.A.	ALBZ
3.	ALRO S.A.	ALR
4.	ALTUR S.A.	ALT
5.	ANTIBIOTICE S.A.	ATB
6.	ARMĂTURA S.A.	ARM
7.	ARTEGO S.A.	ARTE
8.	BERMAS S.A.	BRM
9.	BIOFARM S.A.	BIO
10.	CARBOCHIM S.A.	CBC
11.	CEMACON S.A.	CEON
12.	COMELF S.A.	CMF
13.	COMPA S.A.	CMP
14.	CONTED S.A.	CNTE
15.	ELECTROARGES S.A.	ELGS
16.	ELECTROPUTERE S.A.	EPT
17.	ELECTROCONTACT S.A.	ECT
18.	IAR S.A.	IARV
19.	MECANICA CEAHLĂU S.A.	MECF
20.	MECANICA FINA S.A.	MECE
21.	PREBET S.A.	PREB
22.	PREFAB S.A.	PREH
23.	PRODPLAST S.A.	PPL
24.	RETRASIB S.A.	RTRA
25.	ROMCAB S.A.	MCAB
26.	ROMPETROL RAFINARE S.A.	RRC
27.	ȘANTIERUL NAVAL ORȘOVA S.A.	SNO
28.	STIROM S.A.	STIB
29.	TERAPLAST S.A.	TRP
30.	TMK-ARTROM S.A.	ART
31.	TURBOMECANICA S.A.	TBM
32.	UAMT S.A.	UAM
33.	ZENTIVA S.A.	SCD

6. Performance evaluation of companies

6.1. Performance evaluation with respect to value added indicators

Taking into account the results of the companies on the VFP indicators (EVA, MVA, CFROI, CVA) and their weights, by applying the TOPSIS method (see Algorithm 2) we obtain a hierarchy of the companies in Table 8. The ranking results show that ALR is the first ranked company in terms of value based financial performance value for the years 2011, 2012 and 2015, but surprisingly has recorded the lowest value based financial performance for 2013, in the next financial year taking the third position in the hierarchy. RRC had the lowest value based financial performance value among the analyzed manufacturing companies for 2015, although was ranked first in the hierarchy for 2013 and 2014. Analyzing the hierarchy of the first ten companies in the table above, it is worth mentioning that the best ranked in relation to the value based financial indicators is the machine industry for 2011, 2012 and 2013 as well as the pharmaceutical industry for the years 2014 and 2015.

Table 8. Ranking of the companies in relation to VFP indicators

Rank 2011	Com pany	Perform	Rank 2012	Com pany	Perform	Rank 2013	Com pany	Perform	Rank 2014	Com pany	Perform	Rank 2015	Com pany	Perform
1	ALR	0.65122	1	ALR	0.64008	1	RRC	0.61501	1	RRC	0.53744	1	ALR	0.77399
2	RRC	0.51651	2	RRC	0.51123	2	ATB	0.58755	2	SCD	0.47229	2	SCD	0.65796
3	ELGS	0.51290	3	ATB	0.50123	3	SCD	0.57705	3	ALR	0.46966	3	MCAB	0.65588
4	MECF	0.50258	4	ELGS	0.49678	4	CNTE	0.57243	4	BIO	0.46205	4	TBM	0.64084
5	CNTE	0.50102	5	CNTE	0.48943	5	RTRA	0.57002	5	MCAB	0.45722	5	ALBZ	0.64055
6	RTRA	0.49694	6	MECF	0.48853	6	UAM	0.56931	6	ATB	0.45639	6	ARS	0.63615
7	SCD	0.49430	7	ARTE	0.48504	7	MCAB	0.56915	7	ELGS	0.45622	7	BIO	0.63613
8	ARS	0.49388	8	SCD	0.48174	8	ELGS	0.56870	8	CNTE	0.45449	8	TRP	0.63507
9	ATB	0.49210	9	BRM	0.48164	9	TRP	0.56416	9	ARS	0.45269	9	ELGS	0.63421
10	MCAB	0.49088	10	CMF	0.47951	10	BRM	0.56348	10	MECF	0.45083	10	ATB	0.63128
11	BIO	0.49082	11	UAM	0.47788	11	ARTE	0.56205	11	ALBZ	0.44992	11	ARTE	0.63069
12	CMF	0.49066	12	PREB	0.47717	12	ALBZ	0.56171	12	BRM	0.44708	12	EPT	0.62859
13	BRM	0.49029	13	MCAB	0.47643	13	ARS	0.56141	13	UAM	0.44688	13	BRM	0.62853
14	UAM	0.48565	14	ALBZ	0.47638	14	CEON	0.56081	14	CMF	0.44515	14	CNTE	0.62676
15	ALBZ	0.48540	15	ARS	0.47521	15	EPT	0.56067	15	CEON	0.44487	15	MECF	0.62344
16	PPL	0.48456	16	CMP	0.47451	16	CMF	0.55996	16	ARTE	0.44386	16	UAM	0.62333
17	ARTE	0.48456	17	ART	0.47209	17	BIO	0.55729	17	SNO	0.44289	17	ART	0.62264
18	PREB	0.48451	18	CBC	0.47172	18	PREB	0.55714	18	TRP	0.44006	18	CBC	0.62231
19	CBC	0.48302	19	STIB	0.47029	19	CBC	0.55703	19	IARV	0.43944	19	CMF	0.62193
20	ALT	0.48221	20	CEON	0.46885	20	CMP	0.55681	20	CBC	0.43901	20	PREB	0.62133
21	STIB	0.47960	21	PREH	0.46714	21	MECF	0.55601	21	PREB	0.43654	21	RTRA	0.62033
22	CEON	0.47945	22	RTRA	0.46399	22	PREH	0.55473	22	TBM	0.43586	22	PPL	0.61848
23	IARV	0.47831	23	BIO	0.46320	23	ALT	0.55384	23	ALT	0.43535	23	STIB	0.61797
24	SNO	0.47802	24	MECE	0.46160	24	ARM	0.55315	24	PPL	0.43511	24	SNO	0.61640
25	CMP	0.47738	25	TRP	0.46159	25	ECT	0.55156	25	MECE	0.43307	25	MECE	0.61536
26	ECT	0.47536	26	ECT	0.46146	26	MECE	0.55151	26	PREH	0.43286	26	ECT	0.61409
27	TRP	0.47471	27	IARV	0.46122	27	SNO	0.55102	27	ECT	0.43184	27	ALT	0.61166
28	PREH	0.47409	28	SNO	0.45822	28	ART	0.54863	28	CMP	0.42785	28	PREH	0.61161
29	MECE	0.47255	29	ARM	0.45614	29	IARV	0.54772	29	EPT	0.42501	29	CEON	0.60778
30	ARM	0.47233	30	TBM	0.45568	30	PPL	0.54658	30	ART	0.42401	30	CMP	0.60636
31	EPT	0.46566	31	PPL	0.45490	31	TBM	0.54651	31	STIB	0.41942	31	IARV	0.60616
32	TBM	0.45739	32	ALT	0.45470	32	STIB	0.54628	32	RTRA	0.41354	32	ARM	0.56114
33	ART	0.44089	33	EPT	0.42177	33	ALR	0.32328	33	ARM	0.41205	33	RRC	0.18265

6.2. Performance evaluation with respect to traditional accounting indicators

By applying Algorithm 2 (we recall, it is based on the TOPSIS method) to the results of the companies on the AFP indicators (ROA, ROE, EPS, SOL) and their weights as they were calculated, we obtained the hierarchy of the companies given in Table 9. The ranking results showed that CNTE was the first ranked company in terms of accounting or traditional based financial indicators for the financial years 2011–2014 while MCAB was the first ranked company for 2015. ARM had the lowest value of accounting based financial performance, for the financial year 2011, though was ranked second for 2012 and 2014. Also, CEON was ranked on the last position in the hierarchy for 2012 and 2013. Analyzing the hierarchies we can conclude that the best represented industries are the machine, plastics and pharmaceutical industry.

Table 9. Ranking of the companies in relation to AFP indicators

Rank 2011	Com pany	Perform	Rank 2012	Com pany	Perform	Rank 2013	Com pany	Perform	Rank 2014	Com pany	Perform	Rank 2015	Com pany	Perform
1	CNTE	0.88793	1	CNTE	0.58169	1	CNTE	0.73692	1	CNTE	0.57081	1	MCAB	0.58053
2	ELGS	0.61131	2	ARM	0.47977	2	PPL	0.54376	2	ARM	0.51482	2	ARS	0.53637
3	MECF	0.60312	3	ELGS	0.41305	3	ELGS	0.52530	3	SCD	0.41820	3	CNTE	0.53189
4	ALR	0.58516	4	EPT	0.39598	4	MCAB	0.51381	4	BIO	0.40510	4	ARM	0.46113
5	SCD	0.58455	5	MECF	0.37097	5	BIO	0.51278	5	MCAB	0.38148	5	PPL	0.45660
6	STIB	0.58230	6	BIO	0.34433	6	SCD	0.50637	6	ELGS	0.34667	6	BIO	0.45560
7	ART	0.58015	7	SCD	0.33617	7	ARM	0.49647	7	MECF	0.34462	7	SCD	0.45043
8	BIO	0.57409	8	ARTE	0.33515	8	UAM	0.47480	8	ARS	0.32609	8	TRP	0.44533
9	PPL	0.57330	9	ARS	0.29955	9	EPT	0.46235	9	EPT	0.32246	9	ARTE	0.40521
10	BRM	0.56978	10	CMP	0.29796	10	ARS	0.46105	10	TRP	0.32010	10	IARV	0.35260
11	ARS	0.56939	11	ART	0.29535	11	ATB	0.45578	11	ATB	0.31756	11	ELGS	0.35102
12	ATB	0.55711	12	BRM	0.28716	12	RTRA	0.43924	12	CMP	0.31695	12	ALBZ	0.34525
13	MCAB	0.55460	13	ATB	0.28707	13	ARTE	0.43839	13	SNO	0.31561	13	CMP	0.33463
14	ARTE	0.55395	14	PREB	0.28683	14	CMP	0.43332	14	CMF	0.31019	14	RRC	0.31881
15	CMP	0.55237	15	STIB	0.27799	15	BRM	0.43293	15	ALBZ	0.30695	15	CEON	0.31534
16	CBC	0.54998	16	ALBZ	0.27669	16	ALBZ	0.43117	16	ART	0.29397	16	BRM	0.30726
17	ALBZ	0.54528	17	ALT	0.27611	17	MECE	0.42743	17	IARV	0.29316	17	ATB	0.30460
18	IARV	0.54264	18	MCAB	0.27015	18	TRP	0.42332	18	UAM	0.28747	18	EPT	0.30080
19	MECE	0.54241	19	CMF	0.26729	19	CMF	0.41184	19	ARTE	0.28008	19	STIB	0.28787
20	PREB	0.54195	20	MECE	0.25929	20	ART	0.40074	20	BRM	0.27063	20	TBM	0.28280
21	RTRA	0.53998	21	UAM	0.25618	21	MECF	0.40036	21	STIB	0.26199	21	MECF	0.28263
22	PREH	0.53565	22	PREH	0.24462	22	IARV	0.39813	22	CBC	0.25897	22	CBC	0.27363
23	CMF	0.53460	23	IARV	0.24422	23	STIB	0.39720	23	MECF	0.24577	23	UAM	0.26032
24	UAM	0.53390	24	CBC	0.23442	24	CBC	0.39681	24	PREH	0.23790	24	PREB	0.23436
25	SNO	0.53382	25	PPL	0.22788	25	PREB	0.39569	25	PREB	0.20754	25	MECE	0.22786
26	ALT	0.52848	26	TRP	0.17358	26	ALT	0.39455	26	ALT	0.20214	26	CMF	0.20830
27	ECT	0.50735	27	RTRA	0.17090	27	PREH	0.38680	27	CEON	0.18941	27	PREH	0.18648
28	TRP	0.50428	28	ECT	0.14699	28	SNO	0.34616	28	PPL	0.17771	28	SNO	0.18566
29	CEON	0.50187	29	SNO	0.14172	29	ECT	0.33356	29	ALR	0.16226	29	ART	0.18390
30	RRC	0.48033	30	RRC	0.11945	30	ALR	0.30864	30	TBM	0.15533	30	ALR	0.17995
31	TBM	0.46236	31	TBM	0.11895	31	RRC	0.28067	31	RRC	0.14721	31	RTRA	0.14539
32	EPT	0.41330	32	ALR	0.10543	32	TBM	0.25676	32	ECT	0.11728	32	ALT	0.12608
33	ARM	0.10504	33	CEON	0.05350	33	CEON	0.19714	33	RTRA	0.00653	33	ECT	0.10835

6.3. Performance evaluation with respect to all financial indicators

The weights of value added indicators and accounting based indicators were calculated and have the following values, VFP = 0.569 and AFP = 0.431. By considering the levels of performance on value added indicators and accounting based indicators given in Tables 8 and 9, respectively, for every company, we apply again Algorithm 2. We obtain a hierarchy of companies with respect to all financial indicators considered in the present study (see Table 10). The hierarchy of companies revealed that the most performing company for the analyzed period was CNTE (2011–2014), representing textile and leather garment industry, while the weakest as financial performance are CEON and RRC. The obtained results are not surprising. The best represented industries if we look upon the ranking of the first ten companies are still the pharmaceutical, machine and plastic industries. Also, as we can observe the companies' hierarchy after all financial indicators is more influenced by traditional indicators (AFP) than those based on value added indicators (VFP).

Table 10. Ranking of the companies in relation to all financial indicators (VFP and AFP)

Rank 2011	Com pany	Perform	Rank 2012	Com pany	Perform	Rank 2013	Com pany	Perform	Rank 2014	Com pany	Perform	Rank 2015	Com pany	Perform
1	CNTE	0.77957	1	CNTE	0.81505	1	CNTE	0.93144	1	CNTE	0.88378	1	MCAB	0.87252
2	ALR	0.65412	2	ARM	0.70473	2	PPL	0.66937	2	ARM	0.80187	2	ARS	0.83206
3	ELGS	0.60037	3	ELGS	0.64128	3	ELGS	0.65657	3	SCD	0.71760	3	CNTE	0.81978
4	MECF	0.58437	4	EPT	0.57330	4	MCAB	0.64032	4	BIO	0.69147	4	SCD	0.75788
5	SCD	0.55966	5	MECF	0.56977	5	SCD	0.63424	5	MCAB	0.65061	5	BIO	0.74922
6	STIB	0.54720	6	BIO	0.51440	6	BIO	0.63161	6	ELGS	0.59235	6	PPL	0.75954
7	BIO	0.54664	7	SCD	0.50928	7	ARM	0.60569	7	MECF	0.58698	7	TRP	0.73594
8	ARS	0.54392	8	ARTE	0.50907	8	UAM	0.58570	8	ARS	0.55658	8	ARM	0.69645
9	BRM	0.54189	9	ARS	0.44503	9	ATB	0.57107	9	ATB	0.54341	9	ARTE	0.68309
10	PPL	0.54158	10	CMP	0.44206	10	EPT	0.56318	10	TRP	0.54233	10	ELGS	0.61825
11	ATB	0.53007	11	ART	0.43667	11	ARS	0.56189	11	EPT	0.54119	11	ALBZ	0.61510
12	MCAB	0.52667	12	ATB	0.43464	12	RTRA	0.53858	12	SNO	0.53574	12	IARV	0.60236
13	ARTE	0.52188	13	BRM	0.42657	13	ARTE	0.53209	13	CMP	0.53306	13	CMP	0.58108
14	ART	0.52017	14	PREB	0.42421	14	BRM	0.52596	14	CMF	0.52737	14	BRM	0.56351
15	CBC	0.51680	15	ALBZ	0.40660	15	ALBZ	0.52245	15	ALBZ	0.52342	15	ATB	0.56221
16	CMP	0.51568	16	STIB	0.40646	16	CMP	0.52180	16	IARV	0.49695	16	CEON	0.55958
17	RTRA	0.51533	17	ALT	0.39758	17	TRP	0.51407	17	ART	0.49376	17	EPT	0.55631
18	ALBZ	0.51348	18	MCAB	0.39543	18	MECE	0.51031	18	UAM	0.48955	18	TBM	0.54414
19	PREB	0.50945	19	CMF	0.39174	19	CMF	0.49656	19	ARTE	0.47615	19	STIB	0.53548
20	IARV	0.50629	20	UAM	0.37203	20	MECF	0.47936	20	BRM	0.46103	20	MECF	0.53329
21	CMF	0.50565	21	MECE	0.37130	21	CBC	0.47580	21	STIB	0.43910	21	CBC	0.52308
22	MECE	0.50252	22	PREH	0.34808	22	PREB	0.47451	22	CBC	0.43899	22	ALR	0.51889
23	UAM	0.50178	23	IARV	0.34529	23	ART	0.47415	23	MECE	0.41503	23	UAM	0.51007
24	SNO	0.49701	24	CBC	0.33220	24	ALT	0.47059	24	PREH	0.40161	24	PREB	0.48368
25	PREH	0.49652	25	PPL	0.31500	25	IARV	0.47022	25	PREB	0.35071	25	MECE	0.47386
26	ALT	0.49400	26	ALR	0.27665	26	STIB	0.46794	26	ALT	0.34119	26	CMF	0.46102
27	ECT	0.46778	27	TRP	0.22320	27	PREH	0.46194	27	CEON	0.32183	27	ART	0.44186
28	CEON	0.46432	28	RTRA	0.21953	28	SNO	0.41281	28	PPL	0.29930	28	SNO	0.43932
29	TRP	0.46417	29	ECT	0.17747	29	RRC	0.40684	29	RRC	0.29831	29	PREH	0.43679
30	RRC	0.46319	30	RRC	0.17044	30	ECT	0.40012	30	ALR	0.28429	30	RTRA	0.41422
31	TBM	0.41085	31	SNO	0.16702	31	TBM	0.32934	31	TBM	0.26114	31	ALT	0.39751
32	EPT	0.36135	32	TBM	0.12730	32	CEON	0.31152	32	ECT	0.19490	32	ECT	0.39008
33	ARM	0.05341	33	CEON	0.06455	33	ALR	0.17550	33	RTRA	0.00232	33	RRC	0.29623

6.4. Performance evaluation with respect to nonfinancial indicators

Taking into account the results of the companies on the non-financial indicators (CRTV, PERS, MED, CSR, ETIC, ARTQ, EMPTH) and their weights, by applying the TOPSIS method (see Algorithm 2) we obtain the hierarchy of the companies in Table 11. As regard the non-financial performance obtained values for the analyzed period 2011–2015, ATB stands out clearly from the other analyzed companies as the most performing company, taking the first place in all the years, while PREB, ALBZ, and ALT, are the worst ranked companies. The fact that the latter mentioned companies show a zero-level of non-financial performance level is explained by the lack of disclosure of non-financial variables that we have selected. Surprisingly, CNTE, which was the best ranked company in relation to all financial performance indicators, in terms of non-financial performance was not ranked among the best performing companies. In the top 10 best ranked companies the pharmaceutical industry stands out by placing ATB on the first place and BIO on the 7th place.

Table 11. Ranking of the companies in relation to all non-financial indicators (NFP)

Rank 2011	Com pany	Perform	Rank 2012	Com pany	Perform	Rank 2013	Com pany	Perform	Rank 2014	Com pany	Perform	Rank 2015	Com pany	Perform
1	ATB	0.82632	1	ATB	0.76438	1	ATB	0.80043	1	ATB	0.77539	1	ATB	0.78545
2	CMP	0.47894	2	TRP	0.55103	2	CMP	0.50898	2	CMP	0.50914	2	CMP	0.48717
3	RRC	0.42602	3	CMP	0.52583	3	ALR	0.41967	3	ALR	0.49918	3	ALR	0.39078
4	ARS	0.41602	4	RRC	0.43202	4	RRC	0.40892	4	RRC	0.48194	4	RRC	0.38881
5	ELGS	0.40252	5	MECF	0.40718	5	ELGS	0.39417	5	TRP	0.39793	5	TRP	0.37744
6	PREH	0.38206	6	ELGS	0.40490	6	TRP	0.39182	6	ELGS	0.39350	6	CEON	0.36121
7	ARTE	0.34008	7	BIO	0.38699	7	BIO	0.37709	7	BIO	0.37725	7	BIO	0.34549
8	BIO	0.34008	8	PREH	0.35746	8	ARS	0.34291	8	PREH	0.32217	8	PREH	0.33315
9	ECT	0.32035	9	ARS	0.33832	9	PREH	0.34291	9	ARS	0.32044	9	CMF	0.29676
10	MECF	0.32035	10	ECT	0.32112	10	TBM	0.31327	10	MECF	0.31303	10	ART	0.29676
11	TRP	0.32035	11	TBM	0.30219	11	MECF	0.30984	11	ECT	0.31303	11	ECT	0.28493
12	PPL	0.28196	12	CEON	0.27608	12	ECT	0.30984	12	TBM	0.30830	12	MECF	0.28493
13	SNO	0.26841	13	SNO	0.27026	13	MCAB	0.30984	13	ART	0.29782	13	ELGS	0.28056
14	TBM	0.26841	14	ART	0.26708	14	ART	0.30304	14	CMF	0.29782	14	RTRA	0.26340
15	STIB	0.24620	15	STIB	0.24911	15	CMF	0.30304	15	RTRA	0.25923	15	MCAB	0.25858
16	RTRA	0.24539	16	CMF	0.24911	16	RTRA	0.26272	16	STIB	0.24116	16	SNO	0.23941
17	ART	0.23901	17	RTRA	0.24437	17	STIB	0.24653	17	SNO	0.21517	17	TBM	0.23941
18	SCD	0.22378	18	PPL	0.23771	18	SNO	0.21971	18	SCD	0.21260	18	STIB	0.22546
19	IARV	0.17626	19	SCD	0.22889	19	ARTE	0.21231	19	ARTE	0.20723	19	SCD	0.20222
20	CBC	0.17626	20	ARTE	0.21625	20	SCD	0.21041	20	PPL	0.17245	20	ARTE	0.19400
21	EPT	0.17626	21	ALT	0.18824	21	CBC	0.17650	21	IARV	0.17245	21	PREB	0.19400
22	UAM	0.17626	22	IARV	0.17846	22	EPT	0.17650	22	MCAB	0.17245	22	PPL	0.16064
23	CNTE	0.17626	23	CBC	0.17846	23	CEON	0.17650	23	CBC	0.17245	23	IARV	0.16064
24	CEON	0.13383	24	EPT	0.17846	24	IARV	0.17650	24	UAM	0.17245	24	CNTE	0.16064
25	BRM	0.13383	25	UAM	0.17846	25	UAM	0.17650	25	CNTE	0.17245	25	CBC	0.16064
26	ARM	0.13383	26	CNTE	0.17846	26	CNTE	0.17650	26	BRM	0.13162	26	UAM	0.16064
27	MCAB	0.13383	27	BRM	0.13287	27	ARM	0.13412	27	CEON	0.13162	27	ARS	0.16064
28	ALT	0.13383	28	ARM	0.13287	28	ALT	0.13412	28	ARM	0.13162	28	BRM	0.12171
29	MECE	0.13383	29	MECE	0.13287	29	MECE	0.13412	29	MECE	0.13162	29	ARM	0.12171
30	CMF	0.00000	30	MCAB	0.13287	30	BRM	0.13412	30	EPT	0.11782	30	EPT	0.11082
31	ALBZ	0.00000	31	ALR	0.00000	31	PPL	0.13412	31	ALBZ	0.00000	31	ALBZ	0.00000
32	ALR	0.00000	32	ALBZ	0.00000	32	ALBZ	0.00000	32	ALT	0.00000	32	MECE	0.00000
33	PREB	0.00000	33	PREB	0.00000	33	PREB	0.00000	33	PREB	0.00000	33	ALT	0.00000

6.5. Performance evaluation with respect to all indicators

The weight of the financial indicators is equal to 0.702 and of the non-financial indicators is equal to 0.298. For each company, the level of performance on financial indicators is given in Table 10 and on non-financial indicators in Table 11. We can apply Algorithm 2 on these values to obtain a hierarchy of companies with respect to all indicators considered in the present study (see Table 12). As can be read from the hierarchy of companies in relation to all financial and non-financial performance indicators for the analyzed period, 2011–2015, the best performing company is ATB, followed by ELGS, CNTE and BIO. The least performing companies have proven to be CEON and ALT. If we look at the top ten best performing companies, in respect with all indicators, we can observe that the best performing industry

Table 12. Final ranking of the companies in relation to all indicators (FP and NFP)

Rank 2011	Com pany	Perform	Rank 2012	Com pany	Perform	Rank 2013	Com pany	Perform	Rank 2014	Com pany	Perform	Rank 2015	Com pany	Perform
1	ATB	0.75834	1	ELGS	0.69504	1	ATB	0.66445	1	ATB	0.69443	1	ATB	0.70411
2	ELGS	0.63101	2	CNTE	0.68723	2	CNTE	0.62366	2	BIO	0.68333	2	TRP	0.58966
3	CMP	0.61214	3	MECF	0.63382	3	ELGS	0.57985	3	CNTE	0.67435	3	BIO	0.57362
4	CNTE	0.60169	4	ARM	0.62452	4	BIO	0.55202	4	ARM	0.63329	4	MCAB	0.57269
5	ARS	0.59980	5	ATB	0.60497	5	MCAB	0.52663	5	SCD	0.62739	5	CMP	0.56733
6	MECF	0.57695	6	BIO	0.57427	6	CMP	0.52521	6	ELGS	0.62096	6	ARS	0.50207
7	BIO	0.56174	7	EPT	0.55225	7	ARS	0.47970	7	CMP	0.61720	7	CNTE	0.49618
8	PREH	0.54674	8	CMP	0.55054	8	SCD	0.47801	8	MECF	0.58523	8	SCD	0.48544
9	ARTE	0.54408	9	SCD	0.51413	9	PPL	0.47377	9	TRP	0.58388	9	CEON	0.45868
10	RRC	0.54361	10	ARTE	0.50977	10	TRP	0.46383	10	MCAB	0.57437	10	ALR	0.45233
11	PPL	0.52925	11	ARS	0.48999	11	ARM	0.42718	11	ARS	0.56546	11	PPL	0.45066
12	STIB	0.51626	12	ART	0.45782	12	UAM	0.42700	12	CMF	0.53469	12	ELGS	0.44248
13	SCD	0.51445	13	STIB	0.42234	13	RTRA	0.42395	13	SNO	0.51167	13	ARTE	0.43353
14	ART	0.49413	14	BRM	0.40787	14	EPT	0.40889	14	ART	0.50837	14	ARM	0.40514
15	RTRA	0.49354	15	CMF	0.40776	15	CMF	0.40730	15	EPT	0.48436	15	MECF	0.38305
16	ECT	0.49354	16	PREH	0.40218	16	PREH	0.39805	16	IARV	0.46849	16	TBM	0.35876
17	SNO	0.49076	17	ALT	0.39487	17	ARTE	0.39724	17	ARTE	0.46344	17	IARV	0.35549
18	TRP	0.49075	18	MCAB	0.37753	18	MECF	0.39631	18	UAM	0.46283	18	PREH	0.35494
19	ALR	0.48665	19	PREB	0.37635	19	RRC	0.38886	19	STIB	0.44499	19	STIB	0.34257
20	BRM	0.46569	20	TRP	0.37375	20	ART	0.38882	20	PREH	0.44247	20	CMF	0.34144
21	CBC	0.46487	21	UAM	0.36658	21	BRM	0.36296	21	ALBZ	0.44127	21	RRC	0.33624
22	IARV	0.45735	22	ALBZ	0.36015	22	STIB	0.35766	22	BRM	0.42870	22	ART	0.32925
23	MCAB	0.45535	23	MECE	0.35353	23	MECE	0.34972	23	CBC	0.42312	23	BRM	0.30396
24	UAM	0.45409	24	IARV	0.33965	24	CBC	0.33526	24	RRC	0.42176	24	ALBZ	0.30246
25	MECE	0.43837	25	PPL	0.32778	25	ECT	0.33291	25	ALR	0.41844	25	EPT	0.29272
26	ALT	0.43220	26	CBC	0.32640	26	IARV	0.33043	26	MECE	0.39217	26	CBC	0.29122
27	TBM	0.42364	27	RRC	0.29024	27	ALBZ	0.32483	27	TBM	0.32472	27	ECT	0.29040
28	CEON	0.41009	28	ECT	0.24220	28	ALT	0.31542	28	CEON	0.31459	28	RTRA	0.28593
29	ALBZ	0.40506	29	RTRA	0.24001	29	SNO	0.29923	29	PREB	0.31210	29	SNO	0.28237
30	PREB	0.40238	30	ALR	0.23212	30	PREB	0.28521	30	PPL	0.30702	30	PREB	0.28083
31	CMF	0.39983	31	SNO	0.21037	31	TBM	0.28414	31	ALT	0.30435	31	UAM	0.28045
32	EPT	0.34263	32	TBM	0.20321	32	ALR	0.27843	32	ECT	0.27848	32	MECE	0.18245
33	ARM	0.10120	33	CEON	0.16820	33	CEON	0.19617	33	RTRA	0.16210	33	ALT	0.10796

among all the other manufacturing companies is pharmaceutical industry, represented by ATB, BIO and SCD. As regarding the influence of selected indicators on the final ranking of companies it should be underlined that despite the fact that financial indicators are more relevant in assessing the performance of companies the final ranking taking into account the total performance, showed that non-financial performance indicators are also important in evaluating performance. Indeed, even if ATB is not always ranked in the first ten position, in the analyzed period, with respect to the financial indicators (see Table 10) it becomes the best performing company in relation to all indicators because of the performance on the non-financial indicators (see Table 11). Although, CNTE was the best ranked company in respect to all financial indicators (see Table 10), the influence of non-financial indicators is relevant and pushed the company from the first place, but still remaining among the best performing companies. The position of other companies is also strongly influenced by the performance with respect to the non-financial indicators: CMP and TRP advanced from the middle and last positions in the hierarchy with respect to financial indicators (Table 10) to position in the top ten best ranked companies, respectively, in the final ranking (Table 12), due to a good performance on the non-financial indicators (Table 11). On the other hand, a weak performance with respect to non-financial indicators (see PREB) has important implications on the final hierarchy. Therefore nowadays, business managers should pay more attention and importance to non-financial performance variables and improve their models and methods of internal performance analysis. Such hierarchies of companies by their overall performance are useful not only to managers but also to financial analysts as well as to company shareholders from the perspective of sensitivity analysis, which can render the influence of each indicator on total performance.

Analyzing the hierarchy of companies' performance over the period 2011–2015 (Figure 1), we can highlight four groups of companies: those with good performance throughout the period (ATB, CNTE), those with poor performance (UAM, PREB), those which improved

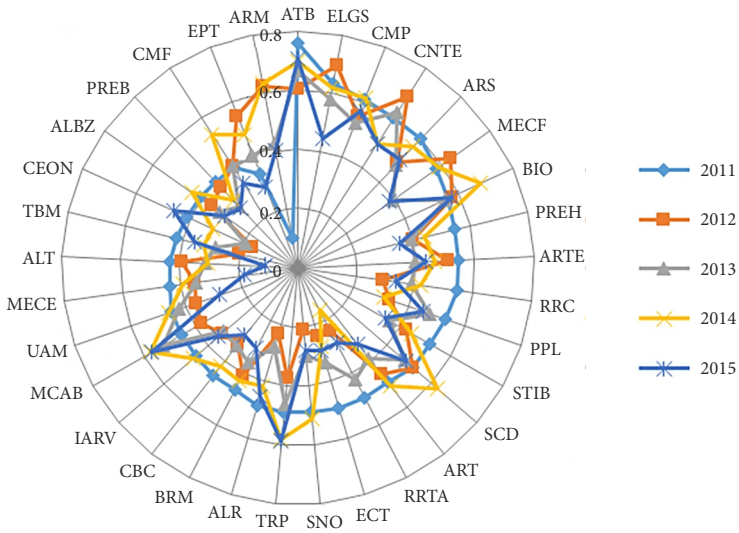

Figure 1. Companies' performances trend during the analyzed period

their performance (BIO, TRP) and those that worsened their performance during the analyzed years (ALT, MECE). The changing dynamics in the hierarchy of companies during the analyzed period is largely influenced by financial indicators but as can be seen in the final hierarchy (Table 12), non-financial indicators have a significant influence on the position of companies according to their overall performance. However, more in-depth analysis would be needed to identify all the causes that generated these differences in the evolution of companies' performance.

Conclusions, limits and further research

In an increasingly competitive business environment, measuring the performance of companies is a permanent management concern in order to improve the market position and to attract new investors. Thus, the performance of companies is the most relevant indicator when it is desired to perform comparative studies within the same industry, field of activity or between sectors of activity. Nowadays, investments in manufacturing industry are increasing. Therewith, performance evaluation of companies becomes more important for managers, shareholders, investors, creditors, stakeholders, as well as for competitors in the same industry.

The aim of this study is to evaluate the total performance of the 33 Romanian manufacturing listed companies, for the period 2011–2015, in order to found out which are the companies with the best performance. In the present paper in order to evaluate the overall performance of the companies in the manufacturing industry, we considered the financial performance as well as the non-financial performance. In this respect we resorted to composite indicators. The usefulness of constructing a composite indicator that shows the performances of the companies lies in the evaluation of these performances and in the identification of the companies that have made progress or worsened their situation during the analyzed period. The quality of a composite indicator, as well as the solidity of the messages it transmits, depends not only on the methodology used in its construction, but first of all on the quality of the theoretical framework and the data used. Therefore, for measuring financial performance (FP) we have built two complex, composite indicators, based on traditional (AFP) and modern value-added indicators (VFP). The ROA, ROE, EPS and SOL indicators were used to determine the composite indicator for the measurement of financial performance through traditional indicators, and the EVA, MVA, CFROI and CVA indicators were used to determine the composite indicator for measuring the financial performance through value added indicators. The composite indicator for evaluating non-financial performance (NFP) was constructed based on 7 indicators, considered significant for the listed companies and the Romanian market. Finally, the determination of the global performance was made based on the 2 composite indicators that measure the financial performance of the companies (FP) and the non-financial performance (NFP).

Fuzzy AHP and TOPSIS is proposed for performance evaluation of manufacturing companies. After the weights for the criteria and sub-criteria are determined using FAHP, these are input to the TOPSIS method to rank the selected companies in respect to their financial, non-financial and total performance.

Although, the determination of non-financial performance criteria involves subjectivity compared to financial criteria (Secme et al., 2009) we think that the proposed method is an efficient method in analyzing both qualitative and quantitative data and it can be successfully applied to performance evaluation of different entities from economy, meaning, private companies, banks, financial institutions or other public or private entities.

According to applied FAHP, the most important financial indicators are EVA and ROA and the most important non-financial indicators are creativity, design, innovation and personnel variables. The results of the performance evaluation of the manufacturing companies taking into consideration financial indicators showed that the best performing companies are CNTE and MCAB, while related to non-financial indicators the best performing company is ATB. As regard the ranking of companies in respect to total performance, the most performing company is ATB. Also, the best performing industry in respect to all performance indicators for the analyzed period, from 2011 to 2015, is the pharmaceutical industry. At the same time, the companies' hierarchy related to all financial indicators is sensitively influenced by accounting based, traditional financial indicators.

As a main conclusion that can be draw from analyzing the results is that not only financial performance, but also non-financial performance indicators should be taken into consideration in the process of total performance evaluation of companies, due to the fact that companies are performing in a very competitive environment. Compared to other similar studies (Rezaie et al., 2014; Moghimi et al., 2013; Ertugrul & Karakasoglu, 2009; Yalcin et al., 2012) we used not just financial indicators to evaluate performance of companies, but also non-financial indicators. As Manes-Rossi et al. (2018) highlighted, in regard to non-financial disclosure of biggest European companies, particular attention is devoted in our times to social, employee and environmental matters. From this point of view, our study is part of current research trends in corporate reporting and disclosure practices and performance evaluation.

The model proposed for assessing the overall performance of companies can serve as a tool for monitoring performance, taking into consideration not only the financial dimension of performance but also the social and environmental issues, too. For these reasons we consider that the approach can be used by small and medium entities, banks or other organizations in their aim to measure and evaluate performance trends over the years.

We are aware of the limits of our study. These can be found in the subjective choices of triangular fuzzy numbers, in the subjectivity of the selection process of the used indicators to evaluate the total performance of companies and finally in the sample selection process of the companies included in our study. On the other hand, the present study could be continued by considering companies from other industries and/or other years. Moreover, the results displayed in Tables 8–12 could be subject of a further processing.

Author contributions

Authors who contributed to the work had the following contributions: A.B. and V.B. conceived the study and were responsible for the design and development of the data analysis, V.B., O.B. and D.T. were responsible for data collection and analysis, A.B., V.B. and D.T. were responsible for data interpretation, D.S.P. and V.B. selected the indicators and wrote the first section, A.B wrote the first draft of the article. A.B., D.T. and V.B. revised the paper.

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