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USING FANP AND FUZZY VIKOR FOR RANKING MANUFACTURING COMPANIES BASED ON THEIR FINANCIAL PERFORMANCE

Abstract. *In the current study a hybrid approach is proposed for financial performance evaluation of manufacturing companies. With respect to inner dependence between financial measures, an analytic structure based on the accounting measures and economic value measures is proposed. Also, based on a type of initial information, it is proposed to evaluate financial performance of companies by applying MCDM (Multiple Criteria Decision Making) methods under fuzzy environment. In this approach Fuzzy Analytic Network Process (FANP) is applied to determine relative significances of multiple criteria used in accounting measures and economic value measures. Then companies are ranked by using Fuzzy VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje; in Serbian) method. In the presented case study, 143 Iranian companies in 14 manufacturing industries that trade on Tehran stock exchange (TSE) are ranked applying the proposed approach. The results represent the importance of hybrid measures in financial performance evaluation of companies.*

Key words: *MCDM (Multiple Criteria Decision Making), fuzzy VIKOR (Fuzzy VlseKriterijumska Optimizacija I Kompromisno Resenje), FANP (Fuzzy Analytic Network Process), financial performance, accounting measures, economic value measures.*

JEL Classification: C44, C81, D46, D81, M41.

1. Introduction

The choice of financial performance measures is one of the most critical challenges facing organizations. Performance measurement systems play a key role in developing strategic plans and evaluating the achievement of organizational objectives in a competitive environment (Venanzi, 2012; Amado *et al.*, 2012).

In today's world economy, firms focused on the maximization of shareholder value need to ensure that all activities yield positive net present value. Accordingly, performance indicators must be carefully identified in the evaluation process (Yalcin *et al.*, 2012). Economic value measures and financial measures have to be integrated in a single performance measurement system in an attempt to guide management actions towards achieving this objective. Also, an accurate and appropriate performance evaluation is very crucial.

The application of Multiple Criteria Decision Making (MCDM) methods significantly improves the robustness of financial analysis and business decisions (Balezentis *et al.*, 2012). MCDM provides decision makers and analysts with a wide range of methodologies, well-suited to the complexity of economical decision problems. Available methodologies and their application for economic decisions are broadly overviewed by Zavadskas and Turskis (2011). Several important new concepts and trends for solving actual multiple criteria problems are considered by Liou and Tzeng (2012). Also new developments of MCDM methods as well as their applications in construction economics are presented by Kaplinski and Tupenaite (2011).

In the current research a hybrid multiple criteria approach is proposed for value based financial performance evaluation of manufacturing companies. An analytic structure based on the accounting measures, consisting of four criteria, and economic value measures, consisting of seven criteria, is proposed for evaluation of companies. Also, based on a type of initial information, it is proposed to evaluate financial performance and rank companies by applying MCDM methods under fuzzy environment: Fuzzy Analytic Network Process (FANP) is applied to determine relative significances of criteria used in accounting measures and economic value measures; companies are ranked by using Fuzzy VIKOR (VlseKriterijumska Optimizacija I Kompromisno Resenje) method.

The case study is presented for the proposed approach. 14 manufacturing industries and 143 companies, that trade on Tehran stock exchange (TSE) in Iran are analysed. Companies are ranked separately in each of manufacturing industries by applying the proposed hybrid fuzzy multiple criteria approach. Based on the presented case study, it is concluded that to achieve better performance evaluation, companies should pay more attention to economic value measures as Market Value Added, Refined Economic Value Added, and True Value Added as well as to Operating Profit Growth as to the most important accounting criterion.

2. Review of recent studies on financial performance assessment by applying MCDM methods

Most of the economical, industrial or financial problems are of multiple criteria nature. Therefore, there are a number of studies available on performance assessment of companies, applying various multiple criteria decision making methods. Recent studies (2009 – 2013) in this area are summarized below.

Secme *et al.* (2009) used FAHP (Fuzzy Analytic Hierarchy Process) and TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) for evaluating of five Turkish banks. Wang and Lee (2010) evaluated three shipment companies by using Grey Relation Analysis (GRA) in their study. Kung *et al.* (2011) applied fuzzy MCDM methods for selecting the best company, based on financial report analysis. The approach used FAHP to select weighting indicators and fuzzy TOPSIS for outranking the five major airlines. Balezentis *et al.* (2012) used fuzzy TOPSIS, fuzzy VIKOR and ARAS-F (Fuzzy Additive Ratio Assessment) methods for integrated assessment of Lithuanian economic, based on financial ratios. Ergul and Seyfullahogullari (2012) applied ELECTRE III for ranking of retail companies trading in Istanbul stock exchange, based on their financial performance in three years period. Lee *et al.* (2012) performed a comparative study on financial positions of shipping companies in Taiwan and Korea. At first the study applied Entropy to find the relative weights of financial ratios of four companies, and then it used GRA to rank the companies. Yalcin *et al.* (2012) constructed a hierarchical structure of the financial performance model for manufacturing company. The approach used FAHP, VIKOR and TOPSIS for calculations. Bayrakdaroglu and Yalcin (2012) proposed to use MCDM for strategic financial performance evaluation of Istanbul stock exchange. The research applied FAHP for determining the relative significances of criteria and VIKOR for the best company selection. Ignatius *et al.* (2012) surveyed financial performance of Iran's Automotive Sector based on PROMETHEE II. Cheng *et al.* (2012) developed an approach combining fuzzy integral with Order Weight Average (OWA) method for evaluating financial performance in the semiconductor industry of Taiwan. Esbouei and Ghadikolaei (2013) performed the study of ranking manufacturer companies based on value and accounting measures. They used FAHP to calculate the weights of criteria and ARAS method to rank alternatives. Ghadikolaei *et al.* (2014) presented the study about financial performance evaluation of companies applying fuzzy MCDM methods, namely FAHP to determine the weights of criteria and fuzzy VIKOR, ARAS-F and fuzzy COPRAS to select best alternative among six Iranian companies. Ghadikolaei and Esbouei (2014) for showing an application of mathematics in a real world, ranked twenty four companies based on their financial performance by integrating FAHP and ARAS-F in their study.

3. Hybrid multiple criteria approach for financial performance evaluation of manufacturing companies

For evaluation of companies, several economic value measures as well as accounting measures are selected from the available different studies. An integrated approach of MCDM methods in fuzzy environment for financial assessment of companies is also presented.

3.1. The analytic structure of companies' financial evaluation

Hierarchal structure for financial evaluation of manufacturing company on the ground of value based financial performance and accounting based financial performance firstly was proposed by Yalcin *et al.* (2012). The current research follows that approach in terms of value based financial performance and accounting based financial performance as two main criteria and each consisting of several sub-criteria. Particular sub-criteria, used in the current approach, are proposed whit respect to experts' recommendations and literature survey. The main sources for development of criteria for accounting measures were Yalcin *et al.* (2012), Ergul and Seyfullahogullari (2012). Sub-criteria for economic value measures are proposed based on Yalcin *et al.* (2012), Bayrakdaroglu and Yalcin (2012), Hajiabasi *et al.* (2012), Jones *et al.* (2011) and Largani *et al.* (2012).

Four sub-criteria for accounting measures are Return On Assets (ROA), Return On Equity (ROE), Operating Profit Growth (OPG), also ratio of market price and earnings (P/E). Seven sub-criteria for economic value measures are Economic Value Added (EVA), Market Value Added (MVA), Refined Economic Value Added (REVA), True Value Added (TVA), Cash Value Added (CVA), Created Shareholder Value (CSV) and Tobin's Q. The proposed analytic structure for companies' financial evaluation is shown in Figure 1.

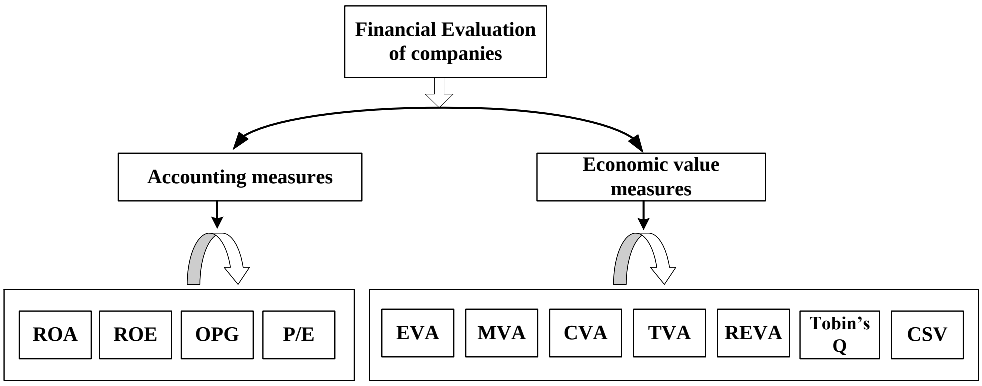

Figure 1. The analytic structure of companies' financial evaluation

3.2. Analytic Network Process and fuzzy extent analysis

In most studies that applied MCDM approach for financial evaluation, the methods for calculating the weights of criteria were used supposing that all criteria are independent, it means increase or decrease in values of one criterion have not any influence on values of other criteria. But with respect to interview results from experts and on the basis of financial literature it can be stated that there is a direct connection between some of the analysed criteria. Accordingly, it is proposed to use FANP for calculating the weights of criteria with considering the inner dependence relationships among them.

The ANP, developed by Saaty (1996), provides a means to input judgments. The ANP also provides measurements to derive ratio scale priorities for the distribution of influence between factors and groups of factors in the decision (Saaty, 2003). Judgments of decision-makers and preferences are hard to quantify in exact numerical values due to the inherent vagueness of human language. The traditional ANP method does not express human thinking completely; therefore, this study uses fuzzy ratios instead of crisp values to handle the difficulty of assigning ratios and derives criteria weights by the geometric mean method. This study applies fuzzy extent analysis (Chang, 1996) to compute the weight vectors of the evaluation criteria (Chou and Cheng, 2012).

Fuzzy extent analysis can be described as follows:

Assume that $O=\{o_1,o_2,o_3,...,o_n\}$, be an object set, and $G=\{g_1,g_2,g_3,...,g_m\}$, be a goal set. Each object is taken and extent analysis for each goal is performed, respectively. Therefore, *m* extent analysis values for each object can be obtained, with the following signs: $\tilde{Q}^1_{g_i},...,\tilde{Q}^2_{g_i},...,\tilde{Q}^m_{g_i},\quad i=1,2,...,\alpha,$ where all the $\tilde{Q}^m_{g_i}$ (j = 1, 2, … , m) are triangular fuzzy numbers (TFNs).

The further steps of extent analysis can be given as follows:

Step 1. The value of fuzzy synthetic extent with respect to the *i*th object is defined as

$$\tilde{S}_i=\sum_{j=1}^{m}\tilde{Q}^j_{g_i}\otimes\left[\sum_{i=1}^{n}\sum_{j=1}^{m}\tilde{Q}^j_{g_i}\right]^{-1}, \tag{1}$$

the next perform the fuzzy addition operation of β extent analysis values for a particular matrix such that:

$$\sum_{j=1}^{m}\tilde{Q}^j_{g_i}=\left(\sum_{j=1}^{m}l_j,\sum_{j=1}^{m}m_j,\sum_{j=1}^{m}u_j\right), \tag{2}$$

and to obtain $\left[\sum_{i=1}^{n}\sum_{j=1}^{m}\tilde{Q}_{g_i}^{j}\right]^{-1}$, perform the fuzzy addition operation of $\tilde{Q}_{g_i}^{j}$ (j = 1, 2, … , β) values such that

$$\sum_{i=1}^{\alpha}\sum_{j=1}^{\beta}\tilde{Q}_{g_i}^{j} = \left(\sum_{i=1}^{\alpha} l_i, \sum_{i=1}^{\alpha} m_i, \sum_{i=1}^{\alpha} u_i\right). \tag{3}$$

Then the inverse of the vector above is computed:

$$\left[\sum_{i=1}^{\alpha}\sum_{j=1}^{\beta}\tilde{Q}_{g_i}^{j}\right]^{-1} = \left(\frac{1}{\sum_{i=1}^{\alpha} u_i}, \frac{1}{\sum_{i=1}^{\alpha} m_i}, \frac{1}{\sum_{i=1}^{\alpha} l_i}\right). \tag{4}$$

Step 2. As $\tilde{Q}_1 = (l_1, m_1, u_1)$ and $\tilde{Q}_2 = (l_2, m_2, u_2)$ are two triangular fuzzy numbers, the degree of possibility of $\tilde{Q}_2 \geq \tilde{Q}_1$ defined as

$$V\left(\tilde{Q}_2 \geq \tilde{Q}_1\right) = \sup_{y \geq x}\left[\min\left(\mu_{\tilde{Q}_1}(x), \mu_{\tilde{Q}_2}(y)\right)\right], \tag{5}$$

and can be equivalently expressed as follows:

$$V\left(\tilde{Q}_2 \geq \tilde{Q}_1\right) = hgt\left(\tilde{Q}_1 \cap \tilde{Q}_2\right) = \mu_{\tilde{Q}_2}(d) = \begin{cases} 1, & if\ m_2 \geq m_1 \\ 0, & if\ l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & O.W \end{cases} \tag{6}$$

where d is the ordinate of the highest intersection point D between $\mu_{\tilde{Q}_1}$ and $\mu_{\tilde{Q}_2}$ (see Fig. 2).

To compare $\tilde{Q}_1$ and $\tilde{Q}_2$, we need both values of $V\left(\tilde{Q}_1 \geq \tilde{Q}_2\right)$ and $V\left(\tilde{Q}_2 \geq \tilde{Q}_1\right)$.

Step 3. The degree possibility for a convex fuzzy number to be greater than k convex fuzzy $\tilde{Q}_1$ (i = 1, 2, … , k) numbers can be defined by

$$V\left(\tilde{Q} \geq \tilde{Q}_1, \tilde{Q}_2, ..., \tilde{Q}_k\right) = V\left[\left(\tilde{Q} \geq \tilde{Q}_1\right) \text{ and } \left(\tilde{Q} \geq \tilde{Q}_2\right) \text{ ... and } \left(\tilde{Q} \geq \tilde{Q}_k\right)\right] = \min V\left(\tilde{Q} \geq \tilde{Q}_1\right), i = 1, 2, 3, ..., k. \quad (7)$$

Assume that $d'(P_i) = \min V(S_i \geq S_k)$ for $k = 1, 2, ..., n;\ k \neq i$. Then the weight vector is given by

$$W' = \left(d'(P_1), d'(P_2), ..., d'(P_n)\right)^T, \quad (8)$$

where $P_i\left(i = 1, 2, ..., n\right)$ are n elements.

Step 4. Via normalization, the normalized weight vectors are

$$W = \left(d(P_1), d(P_2), ..., d(P_n)\right)^T, \quad (9)$$

where W is a non-fuzzy number.

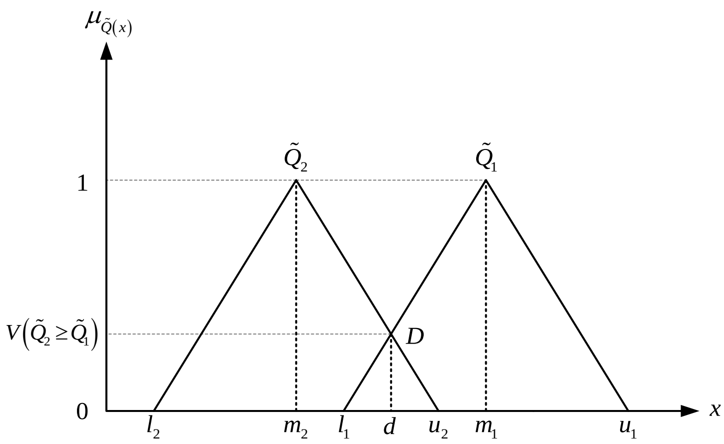

Figure 2. The intersection between $\tilde{Q}_1$ and $\tilde{Q}_2$

Calculation steps of FANP are described as follows (Chou and Cheng, 2012):

Step 1: Conducting pairwise comparisons on the elements using the scale given in Table 1.

Step 2: Computing relative importance weights for each element and testing the consistency ratio (CR).

Step 3: Placing the results of these computations within the unweighted supermatrix.

Step 4: Performing pairwise comparisons on the clusters with respect to the given control criterion, as they influence each cluster to which they are connected.

Step 5: Weighting the blocks of the unweighted supermatrix by the corresponding cluster priorities, such that the result is column-stochastic (weighted supermatrix).

Step 6: To achieve convergence of the importance weights, the weighted (stochastic) supermatrix is raised to power. This matrix is called the limit supermatrix.

Next the relative weights of all criteria obtained in the limit supermatrix are integrated with performance values of the alternatives using Fuzzy VIKOR method.

3.3. Fuzzy VIKOR method

Based on crisp VIKOR that was widely introduced by Opricovic and Tserng (2004), fuzzy VIKOR was developed later and presented in several studies (Antucheviciene *et al*., 2011; Antucheviciene *et al*., 2012; Chou and Cheg, 2012; Vinodh *et al.*, 2013). VIKOR is based on measuring the closeness to the ideal alternative according to separate cases of L_p metric (Balezentis *et al.* 2012). Let us assume the fuzzy decision making matrix $\tilde{D} = \tilde{d}_{ij}$, where $i = 1, 2, ..., m$ and $j = 1, 2, ..., n$ represent the number of alternatives and criteria, respectively. The *j*th criterion of the *i*th alternative is represented by triangular fuzzy number $\tilde{d}_{ij} = \left(d_{ij_1}, d_{ij_2}, d_{ij_3}\right)$. Also each *j*th criterion is assigned with respective coefficient of significance $\tilde{w}_j$, that it obtained by FANP. Benefit criteria are members of benefit criteria set *B*, while cost criteria are members of respective set *C*. Computing of fuzzy VIKOR consists of the following steps:

Step 1. The fuzzy best values $\tilde{f}_j^+$ and the fuzzy worst values $\tilde{f}_j^-$ are found:

$$\begin{aligned} \tilde{f}_j^+ &= \max_i \tilde{d}_{ij}, & \tilde{f}_j^- &= \min_i \tilde{d}_{ij}, \forall j \in B, \\ \tilde{f}_j^+ &= \min_i \tilde{d}_{ij}, & \tilde{f}_j^- &= \max_i \tilde{d}_{ij}, \forall j \in C. \end{aligned} \tag{10}$$

Step 2. The distances of each alternative from the ideal one are determined:

$$\tilde{S}_i = \sum_{i=1}^{n} \tilde{w}_j \left(\tilde{f}_j^+ - \tilde{d}_{ij} \right) / \left(\tilde{f}_j^+ - \tilde{f}_j^- \right), \forall i, \tag{11}$$

$$\tilde{R}_i = \max\left[\tilde{w}_j\left(\tilde{f}_i^+ - \tilde{d}_{ij}\right)/\left(\tilde{f}_j^+ - \tilde{f}_j^-\right)\right], \forall i. \quad (12)$$

Step 3. The reference point is defined by computing values of $\tilde{S}^+$, $\tilde{S}^-$, $\tilde{R}^+$, and $\tilde{R}^-$, which, in turn, enable to obtain the final summarizing ratio $\tilde{Q}_i$:

$$\tilde{S}^+ = \min_i \tilde{S}_i,\ \tilde{S}^- = \max_i \tilde{S}_i,\ \tilde{R}^+ = \min_i \tilde{R}_i,\ \tilde{R}^- = \max_i \tilde{R}_i, \quad (13)$$

$$\tilde{Q}_i = \nu\left(\tilde{S}_i - \tilde{S}^+\right)/\left(\tilde{S}^- - \tilde{S}^+\right) + (1-\nu)\left(\tilde{R}_i - \tilde{R}^+\right)/\left(\tilde{R}^- - \tilde{R}^+\right), \forall i. \quad (14)$$

Step 4. Defuzzifying triangular fuzzy numbers $\tilde{S}_i$, $\tilde{R}_i$, and $\tilde{Q}_i$ into crisp values. A center of area (COA) defuzzification method is used to determine the best non-fuzzy performance (*BNP*). The *BNP* value of the triangular fuzzy number (l_i, m_i, u_i) can be found by the following equation:

$$BNP_i = \frac{l_i + m_i + u_i}{3}, \forall i. \quad (15)$$

Step 5. Ranking the alternatives, sorting by the values S_i, R_i and Q_i, in the decreasing order. The results are three ranking lists.

Step 6. Proposing the alternative (a') as a compromise solution for given criteria weights, which is the best ranked by the measure Q if the following two conditions are satisfied:

C1. "Acceptable advantage": $Q(a'') - Q(a') \geqslant DQ$, where a'' is the alternative with second position in the ranking list by Q; $DQ = \frac{1}{m-1}$; m is the number of alternatives.

C2. "Acceptable stability in decision making": Alternative a' must also be the best ranked by S or/and R. This compromise solution is stable within a decision making process, which could be: "voting by majority rule" (when $v > 0.5$ is needed), or "by consensus" $v \approx 0.5$, or "with veto" ($v < 0.5$). Here, v is the weight of the decision making strategy "the majority of criteria" (or "the maximum group utility").

If one of the conditions is not satisfied, then the set of compromise solutions is proposed, which consists of:

Alternatives a' and a'', if only the condition C2 is not satisfied;

Alternatives a', a'', …, $a^{(k)}$, if the condition C1 is not satisfied; $a^{(k)}$ is determined by the relation $Q(a^{(k)}) - Q(a') \approx DQ$, the positions of these alternatives are "in closeness".

4. Case study of Iranian manufacturing companies for applications of the proposed approach

The application of the proposed integrated multiple criteria approach for financial performance evaluation of manufacturing companies is presented for the companies in the Iran, trading on Tehran stock exchange. 143 manufacturing companies in 14 industries were selected for this study. In a period of ten years (2002-2011) annual financial statements of companies were considered. Data was gathered from the TSE's Database and using Rahavard Novin software.

4.1. Determining the weights of sub-criteria for performance measures

Whit respect to the calculation steps of FANP, to evaluate the importance of the main criteria and sub-criteria and to compose the fuzzy pairwise matrix, expert group (decision makers) utilized the membership function of linguistic scale. The scale is presented in Table 1.

Table 1. Membership function of linguistic scale (Chou, Cheng 2012)

Linguistic scale	Positive triangular fuzzy numbers	Positive reciprocal triangular fuzzy numbers
Absolutely importance	(8, 9, 10)	(1/10, 1/9, 1/8)
Intermediate	(7, 8, 9)	(1/9, 1/8, 1/7)
Very strongly	(6, 7, 8)	(1/8, 1/7, 1/6)
Intermediate	(5, 6, 7)	(1/7, 1/6, 1/5)
Strong	(4, 5, 6)	(1/6, 1/5, 1/4)
Intermediate	(3, 4, 5)	(1/5, 1/4, 1/3)
Weakly	(2, 3, 4)	(1/4, 1/3, 1/2)
Intermediate	(1, 2, 3)	(1/3, 1/2, 1)
Equally importance	(1, 1, 1)	(1, 1, 1)

The pairwise comparison scores have been carried out by financial experts. Experts were asked to make pairwise comparisons for all economic value and accounting evaluation criteria based on Figure 1. In this study for testing the consistency ratio (CR) of fuzzy pairwise matrix, Lin (2010) approach was used. Calculated consistency ratio values were less than the acceptable threshold value (i.e. CR < 0.1).

The overall results were obtained by taking the geometric mean of individual evaluations. Then for calculating the FANP steps unweighted supermatrix was consisted. Table 2 shows the unweighted supermatrix. Table 3 shows the convergence supermatrix.

Table 4 shows the weights of the sub-criteria that were obtained by using FANP. MVA, REVA, CVA have the highest weight among sub-criteria, therefore Iranian manufacturing companies should pay special attention to these measures.

Table 2. Unweighted supermatrix

	Goal	D1	D2	ROA	ROE	OPG	P/E	EVA	MVA	CVA	TVA	REVA	Q	CSV
Goal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D1	0.2332	0	0	0	0	0	0	0	0	0	0	0	0	0
D2	0.7668	0	0	0	0	0	0	0	0	0	0	0	0	0
ROA	0	0.2431	0	0.0000	0.4155	0.2823	0.1747	0	0	0	0	0	0	0
ROE	0	0.2089	0	0.3649	0.0000	0.3044	0.1747	0	0	0	0	0	0	0
OPG	0	0.2689	0	0.4477	0.4677	0.0000	0.6506	0	0	0	0	0	0	0
P/E	0	0.2791	0	0.1873	0.1167	0.4132	0.0000	0	0	0	0	0	0	0
EVA	0	0	0.1040	0	0	0	0	0.0000	0.2764	0.1083	0.1250	0.1781	0.1743	0.1464
MVA	0	0	0.1359	0	0	0	0	0.3461	0.000	0.2185	0.2192	0.2315	0.2362	0.2236
CVA	0	0	0.1823	0	0	0	0	0.2187	0.1489	0.000	0.186	0.1382	0.1863	0.2093
TVA	0	0	0.1764	0	0	0	0	0.1407	0.1354	0.1948	0.000	0.1867	0.1685	0.1136
REVA	0	0	0.1668	0	0	0	0	0.1000	0.2604	0.1848	0.2319	0.000	0.1273	0.1887
Q	0	0	0.1031	0	0	0	0	0.0881	0.0623	0.1566	0.1207	0.1379	0.000	0.1184
CSV	0	0	0.1315	0	0	0	0	0.1064	0.1166	0.1370	0.1166	0.1275	0.1073	0.0000

Table 3. Convergence supermatrix

	Goal	D1	D2	ROA	ROE	OPG	P/E	EVA	MVA	CVA	TVA	REVA	Q	CSV
Goal	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D1	0	0	0	0	0	0	0	0	0	0	0	0	0	0
D2	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ROA	0.0525	0.2251	0	0.2252	0.2252	0.2252	0.2252	0	0	0	0	0	0	0
ROE	0.0519	0.2223	0	0.2224	0.2224	0.2224	0.2224	0	0	0	0	0	0	0
OPG	0.0795	0.3407	0	0.3408	0.3408	0.3408	0.3408	0	0	0	0	0	0	0
P/E	0.0487	0.2089	0	0.2090	0.2090	0.2090	0.2090	0	0	0	0	0	0	0
EVA	0.1145	0	0.1494	0	0	0	0	0.1494	0.1494	0.1494	0.1494	0.1494	0.1494	0.1494
MVA	0.1522	0	0.1985	0	0	0	0	0.1985	0.1985	0.1985	0.1985	0.1985	0.1985	0.1985
CVA	0.1153	0	0.1504	0	0	0	0	0.1504	0.1504	0.1504	0.1504	0.1504	0.1504	0.1504
TVA	0.1041	0	0.1357	0	0	0	0	0.1357	0.1357	0.1357	0.1357	0.1357	0.1357	0.1357
REVA	0.1217	0	0.1587	0	0	0	0	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587	0.1587
Q	0.0766	0	0.0999	0	0	0	0	0.0999	0.0999	0.0999	0.0999	0.0999	0.0999	0.0999
CSV	0.0816	0	0.1064	0	0	0	0	0.1064	0.1064	0.1064	0.1064	0.1064	0.1064	0.1064

Table 4. Weights of sub-criteria obtained from FANP

Sub-criteria	Total Weights	Rank
ROA	0.0525	9
ROE	0.0519	10
OPG	0.0795	7
P/E	0.0487	11
EVA	0.1146	4
MVA	0.1522	1
CVA	0.1153	3
TVA	0.1040	5
REVA	0.1217	2
Tobin’s Q	0.0766	8
CSV	0.0816	6

4.2. Evaluation of companies

As was mentioned, 143 Iranian companies in 14 industries are selected. Names of industry sectors and the number of the companies analysed in each sector are given in Table 5.

Table 5. Sectors and the number of companies in each sector in TSE

Sectors	Number of companies
Ceramic & Tiles	5
Cement, Lime & Plaster	14
Chemicals & Chemical products except Pharmaceutical Products	16
Motor Vehicles and Auto Parts	24
Refined Petroleum Products & Nuclear Fuel	5
Machinery & Equipment	9
Rubber & Plastic Products	9
Food Products and Beverages except sugar	15
Sugar & By-products	6
Basic Metals	14
Fabricated Metal Products except Machinery & Equipment	7
Pharmaceutical & Medicinal Products	19

The following approach was used for convert crisp numbers of financial measures into fuzzy numbers. As for time series data, when x_{ij} is the value of jth criterion of ith alternative in each year (2002-2011), a fuzzy number can represent the dynamics of certain indicator during past t=10 periods (Balezentis *et al.*, 2012):

$$\left(Min(x_{ij}), \frac{\sum_{i=1}^{10} x_{ij}}{10}, Max(x_{ij}) \right), \forall i, \forall j. \qquad (16)$$

Next Fuzzy VIKOR is used to rank the companies. At first the value of v is considered 0.5, and then different values of v are considered for obtaining different values of Q_i.

Table 6 shows the results of fuzzy VIKOR for Ceramic & Tiles industry. As one can see from the Table 6, KHFZ has the minimum score with respect to the Q values; also conditions of “Acceptable advantage” and “Acceptable stability” in decision making are satisfied by this alternative. Accordingly, KHFZ is chosen as the best company in terms of financial performance among other companies. Also KHFZ is the best company with respect to other values of v in Ceramic & Tiles companies traded on TSE in 2002-2011.

Table 6. Ranking of companies in Ceramic & Tiles industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
KPRS	1.2098	3	0.4711	2	3.3246	3	4.7028	4.1859	2.4632	1.9462
ALVN	1.2055	2	0.5882	4	2.5180	2	3.8489	3.3498	1.6862	1.1870
CHIR	1.2132	4	0.6574	5	4.0470	5	6.2660	5.4339	2.6602	1.8280
KHFZ	0.8266	1	0.2824	1	0.1665	1	0.1591	0.1619	0.1711	0.1739
KSAD	1.3178	5	0.5326	3	4.0139	4	5.8099	5.1364	2.8913	2.2177

Table 7 shows the results of Cement industry evaluation. As one can see from the Table 7, SKAZ has the minimum score with respect to the Q values; also conditions of “Acceptable advantage” and “Acceptable stability” in decision making are satisfied by this alternative. Accordingly, SKAZ is chosen as the best company in terms of financial performance among other companies. Also the same company is the best company with respect to other values of v in Iranian Cement industry.

Table 7. Ranking of companies in Cement, Lime & Plaster industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
SKAZ	0.6725	1	0.2133	1	0.0818	1	0.0563	0.0659	0.0977	0.1072
SSHR	1.0694	6	0.4457	9	1.1853	2	1.5746	1.4286	0.9419	0.7959
SIMS	1.1607	10	0.5077	13	1.9568	9	2.7910	2.4782	1.4354	1.1225
IRGC	1.2080	13	0.3837	3	1.9425	8	2.4227	2.2426	1.6424	1.4623
SADB	0.9757	3	0.4652	10	1.9653	10	2.9191	2.5614	1.3692	1.0115
SEFH	1.2002	12	0.4708	11	2.1490	13	2.9332	2.6391	1.6588	1.3647
SBOJ	0.9977	5	0.3646	2	1.4531	3	1.9555	1.7671	1.1391	0.9508
SKHS	1.1239	9	0.3896	4	1.7870	6	2.3565	2.1429	1.4310	1.2174
SSNR	1.1868	11	0.3949	6	1.9775	11	2.5405	2.3294	1.6257	1.4146
SGRB	0.9873	4	0.3945	5	1.6855	5	2.3924	2.1273	1.2437	0.9786
SGEN	1.3495	14	0.7831	14	2.3458	14	3.3395	2.9669	1.7248	1.3522
SHGN	0.9495	2	0.4208	8	1.6825	4	2.4494	2.1618	1.2032	0.9156
SKOR	1.0860	7	0.3982	7	1.7944	7	2.4026	2.1745	1.4143	1.1862
SKER	1.1154	8	0.5069	12	2.0754	12	2.9709	2.6351	1.5157	1.1799

Table 8 shows the results of Chemicals industry. As one can see from the Table 8, SSIN has the minimum score with respect to the Q values; also conditions of “Acceptable advantage” and “Acceptable stability” in decision making are satisfied by this alternative. Accordingly, SSIN is chosen as the best company with huge advantage in terms of financial performance among other companies traded on TSE Chemicals & Chemical products industry.

Table 8. Ranking of companies in Chemicals & Chemical products except Pharmaceutical Products industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
CRBN	30.1480	2	18.2434	2	83.2938	3	112.9089	101.8032	64.7844	53.6788
PLAK	30.2458	8	18.2615	12	83.4584	8	113.0861	101.9757	64.9411	53.8308
PPAM	30.2775	12	18.2594	11	83.5202	16	113.0870	101.9995	65.0410	53.9534
SHRG	30.2858	13	18.2585	9	83.5173	15	113.0789	101.9933	65.0413	53.9557
LEAB	30.2313	5	18.2481	3	83.4341	6	112.9935	101.9087	64.9595	53.8747
BMPS	30.2395	7	18.2562	7	83.4725	10	113.0523	101.9599	64.9852	53.8928
PAKS	30.2375	6	18.2555	5	83.4631	9	113.0507	101.9553	64.9708	53.8755
TOPI	30.2598	10	18.2575	8	83.5015	14	113.0752	101.9851	65.0178	53.9277
GTSH	30.2589	9	18.2560	6	83.4893	12	113.0562	101.9686	65.0100	53.9224
PKHA	31.9011	16	19.7552	16	83.3042	4	113.1509	101.9584	64.6500	53.4575
NKOL	30.2682	11	18.2496	4	83.4562	7	113.0062	101.9249	64.9874	53.9062
SHFS	30.3299	14	18.3005	13	83.4932	13	113.0589	101.9718	65.0145	53.9274
AMLH	30.2067	4	18.2585	10	83.3858	5	112.9587	101.8689	64.9028	53.8129
MAVA	30.3652	15	18.3290	15	83.4839	11	113.0633	101.9710	64.9967	53.9044
PARK	30.1517	3	18.3116	14	83.2366	2	112.9752	101.8233	64.6500	53.4981
SSIN	6.1755	1	4.5038	1	0.0288	1	0.0254	0.0266	0.0309	0.0322

As one can see from the results of evaluation of Motor Vehicles industry in Table 9, RENA has the minimum score with respect to the Q values; also conditions of “Acceptable advantage” and “Acceptable stability in decision making” are satisfied by this alternative. Accordingly, RENA is chosen as the best company in terms of financial performance in Motor Vehicles and Auto Parts industry.

As seen in Table 10, the best ranked company for the Refined Petroleum Products & Nuclear Fuel sector is PNES company with respect to Q value and both conditions, also with other values of v.

As one can see from the Table 11, HPKO has the minimum score with respect to the Q values in Machinery & Equipment sector, also conditions of “Acceptable advantage” and “Acceptable stability in decision making” are satisfied by this alternative. Accordingly, HPKO is chosen as the best company in terms of financial performance among other companies. Also it is shown that HPKO is the best company with respect to other value of v among all Machinery & Equipment companies, traded on TSE in 2002-2011.

Table 12 shows the results of evaluation of companies in Rubber & Plastic industry. With respect to the Q value (v=0.5), SHND is the best company; also C2 (condition of “Acceptable advantage”) is satisfied but C2 (“Acceptable stability in decision making") is not satisfied by this alternative. Based on the VIKOR algorithm, all the alternatives that satisfy $Q(a^{(k)}) - Q(a') \approx DQ$ are proposed as a compromise solution and the positions of these alternatives are in closeness. Therefore in this situation SHND, YASA and ARTA are proposed as a compromise solution. When v=0.1 or v=0.9, the previous situation is confirmed. When v=0.75, SHND has minimum Q but only C2 is satisfied, accordingly SHND, BARZ and YASA are the best alternatives. Ultimately, when v=0.75, SHND has the best Q, but only C2 is satisfied. Accordingly, SHND and BARZ are proposed as a compromise solution.

Table 9. Ranking of companies in Motor Vehicles and Auto Parts Industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
IKCO	1.0848	2	0.6819	3	1.0574	3	1.6528	1.4295	0.6852	0.4619
KAVR	1.7729	12	0.7413	18	2.1229	8	2.4994	2.3582	1.8877	1.7465
PKOD	1.7463	11	0.7287	4	2.1040	7	2.4860	2.3427	1.8653	1.7221
SIPA	1.4299	4	0.7415	19	1.4435	4	1.9118	1.7362	1.1508	0.9752
RENA	0.9035	1	0.3887	1	0.0304	1	0.0333	0.0322	0.0286	0.0275
BHMN	1.4242	3	0.5506	2	1.0316	2	1.1008	1.0748	0.9884	0.9625
ATIR	1.8099	20	0.7450	22	2.2263	16	2.6042	2.4625	1.9901	1.8484
KRIR	1.7259	8	0.7337	9	2.1722	11	2.5887	2.4325	1.9118	1.7556
RADI	1.7795	13	0.7344	10	2.2171	14	2.5957	2.4537	1.9804	1.8384
RTIR	1.7454	10	0.7370	16	2.1781	12	2.5901	2.4356	1.9205	1.7660
RINM	1.8252	24	0.7344	11	2.2581	23	2.6010	2.4724	2.0437	1.9151
ZMYD	1.6940	6	0.7436	21	2.0609	6	2.5124	2.3431	1.7786	1.6093
SZPO	1.5650	5	0.7482	23	2.0025	5	2.5544	2.3475	1.6575	1.4505
AZIN	1.7975	17	0.7350	12	2.2305	17	2.5995	2.4611	1.9999	1.8616
RIIR	1.7873	14	0.7402	17	2.2151	13	2.6007	2.4561	1.9741	1.8295
KFAN	1.8007	18	0.7358	15	2.2391	19	2.6032	2.4667	2.0116	1.8751
FNAR	1.8027	19	0.7357	14	2.2402	20	2.6044	2.4679	2.0126	1.8760
GHAT	1.7949	16	0.8839	24	2.2680	24	2.8615	2.6389	1.8970	1.6745
LENT	1.7185	7	0.7335	8	2.1677	10	2.5885	2.4307	1.9047	1.7468
TMKH	1.8197	23	0.7322	6	2.2375	18	2.5797	2.4514	2.0236	1.8952
MESI	1.7889	15	0.7335	7	2.2188	15	2.5904	2.4511	1.9865	1.8471
MHKM	1.7377	9	0.7317	5	2.1503	9	2.5528	2.4019	1.8987	1.7478
NMOH	1.8141	22	0.7351	13	2.2441	21	2.5962	2.4642	2.0240	1.8919
INDM	1.8123	21	0.7428	20	2.2442	22	2.6104	2.4731	2.0152	1.8779

Table 10. Ranking of companies in Refined Petroleum Products & Nuclear Fuel Industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
PNTB	2.1701	2	1.4875	3	8.2359	2	10.9648	9.9415	6.5304	5.5070
PNES	0.7203	1	0.3922	1	0.3346	1	0.3393	0.3376	0.3316	0.3299
NAFT	2.2492	5	1.4128	2	8.2435	3	10.6005	9.7167	6.7704	5.8866
NBEH	2.1899	3	1.5160	4	8.3505	4	11.1828	10.1207	6.5803	5.5182
NPRS	2.2099	4	1.5649	5	8.9453	5	12.0073	10.8590	7.0316	5.8833

Table 11. Ranking of companies in Machinery & Equipment industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
HPKO	0.7554	1	0.3137	1	0.1712	1	0.3033	0.2538	0.0887	0.0391
SRMA	6.8482	8	3.3461	5	22.6417	9	28.1950	26.1125	19.1708	17.0883
GSKE	6.7701	5	3.3410	3	22.4857	5	28.0827	25.9839	18.9876	16.8887
PIRN	6.8106	6	3.3452	4	22.5367	7	28.1090	26.0194	19.0541	16.9645
AZMA	6.3212	2	3.2443	2	21.1691	2	26.8781	24.7372	17.6009	15.4600
BOTA	6.6330	3	3.3714	9	22.3004	3	28.1332	25.9459	18.6550	16.4677
LKPS	6.8599	9	3.3678	8	22.6049	8	28.2540	26.1356	19.0743	16.9559
KHAZ	6.8179	7	3.3493	6	22.5318	6	28.1073	26.0165	19.0471	16.9563
TSHE	6.7137	4	3.3666	7	22.4753	4	28.2228	26.0675	18.8831	16.7278

Table 12. Ranking of companies in Rubber & Plastic Products industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
SHND	0.5384	1	0.1712	2	0.2702	1	0.2907	0.2830	0.2574	0.2497
SHIN	0.7180	4	0.1875	3	0.5229	5	0.4755	0.4933	0.5526	0.5703
PLKK	0.9308	9	0.3250	9	0.9793	9	1.1089	1.0603	0.8983	0.8498
DRKH	0.7410	6	0.1956	4	0.5862	6	0.5409	0.5579	0.6146	0.6315
KVRZ	0.9304	8	0.2919	8	0.9002	8	0.9411	0.9258	0.8747	0.8594
ARTA	0.7334	5	0.2043	5	0.3810	3	0.3039	0.3328	0.4292	0.4581
TAIR	0.7820	7	0.2521	6	0.6541	7	0.6890	0.6759	0.6323	0.6192
YASA	0.6034	3	0.1712	1	0.3559	2	0.3212	0.3342	0.3776	0.3906
BARZ	0.5663	2	0.2577	7	0.4472	4	0.6283	0.5604	0.3341	0.2662

As seen in Table 13, the best ranked company for the Food Products and Beverages sector is CHCH company with respect to Q value and both conditions. Also this company is proposed as a compromise solution in other values of v.

The best ranked company for the Sugar & By-products sector is GGAZ company with respect to Q value and both conditions. When other values of v are applied, this company is proposed as a compromise solution (Table 14).

The best ranked company for the Fabricated Metal Products except Machinery & Equipment industries sector is MARK company with respect to Q value and both conditions. Also this company is proposed as a compromise solution in other values of v (Table 15).

Table 16 shows the results of evaluation of companies traded in Basic metals. With respect to the Q value (v=0.5), FOLD is the best company, also condition of "Acceptable advantage" is satisfied, but "Acceptable stability in decision making" is not satisfied by this alternative. Accordingly, FOLD and KSIM (that has a minimum Q after FOLD) are proposed as a compromise solution. The results of different values of v produced the same situation.

Table 13. Ranking of companies in Food Products and Beverages except sugar industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
GCOZ	1.2958	6	0.7939	9	3.0829	8	4.3363	3.8663	2.2996	1.8295
DMOR	1.3398	12	0.7882	7	3.1037	11	4.3326	3.8718	2.3357	1.8748
SHAD	1.3561	13	0.7973	11	3.1120	12	4.3631	3.8939	2.3301	1.8609
NOSH	1.3000	7	0.7872	6	3.0792	6	4.3379	3.8659	2.2925	1.8204
PIAZ	1.3349	10	0.7901	8	3.1171	13	4.3617	3.8950	2.3393	1.8726
KDPS	1.3163	9	0.7814	4	3.0903	9	4.3282	3.8640	2.3166	1.8524
CHCH	0.4843	1	0.1840	1	0.0149	1	0.0127	0.0135	0.0163	0.0171
TSBE	1.6105	15	1.2005	15	3.1675	14	4.5949	4.0596	2.2753	1.7400
SHPZ	1.2493	3	0.7568	3	2.8825	3	4.0908	3.6377	2.1273	1.6742
SPPE	1.2944	5	0.7971	10	3.0633	5	4.3354	3.8583	2.2682	1.7912
LPAK	1.3359	11	0.8060	12	3.0906	10	4.3515	3.8787	2.3025	1.8296
GORJ	1.2942	4	0.7837	5	3.0824	7	4.3383	3.8673	2.2975	1.8266
SLMN	1.5551	14	0.9520	14	3.2307	15	4.4737	4.0076	2.4538	1.9877
KIVN	1.2149	2	0.6550	2	2.5050	2	3.4335	3.0853	1.9247	1.5765
BENN	1.3011	8	0.8285	13	3.0494	4	4.3297	3.8496	2.2492	1.7691

Table 14. Ranking of companies in Sugar & By-products industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
GSBE	1.5832	6	0.5141	6	2.3570	6	2.4943	2.4428	2.2711	2.2196
GMRO	0.9061	3	0.4555	4	1.3807	3	1.7947	1.6395	1.1220	0.9667
GPSH	0.8004	2	0.3416	2	1.1107	2	1.2891	1.2222	0.9991	0.9322
GSHI	1.4737	5	0.4649	5	2.1617	5	2.2362	2.2083	2.1152	2.0873
GGAZ	0.5842	1	0.2499	1	0.2107	1	0.1874	0.1961	0.2252	0.2340
GNBO	1.2326	4	0.4431	3	2.0331	4	2.2354	2.1596	1.9067	1.8309

Table 15. Ranking of companies in Fabricated Metal Products except Machinery & Equipment industries

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
LAMI	0.8042	3	0.3867	5	0.8641	3	1.2286	1.0919	0.6363	0.4996
SAMA	1.0231	6	0.4640	6	0.9255	5	1.1274	1.0517	0.7993	0.7236
BMAS	0.9265	5	0.3515	3	0.9363	6	1.2032	1.1031	0.7695	0.6694
JAMD	0.7553	2	0.3341	2	0.8142	2	1.1318	1.0127	0.6157	0.4966
JSHP	0.8647	4	0.3523	4	0.9106	4	1.1975	1.0899	0.7314	0.6238
AZAB	1.1320	7	0.5474	7	1.1265	7	1.4349	1.3193	0.9337	0.8181
MARK	0.6618	1	0.2848	1	0.1883	1	0.1830	0.1850	0.1916	0.1936

Table 16. Ranking of companies in Basic Metals industry

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
SDID	0.8489	3	0.3318	7	0.7245	3	0.9338	0.8553	0.5938	0.5153
LSDP	0.9667	9	0.3313	6	0.8027	5	0.9235	0.8782	0.7272	0.6819
FRIS	1.0072	12	0.3513	12	0.8450	12	0.9776	0.9279	0.7621	0.7124
FOLD	0.8110	2	0.3269	4	0.2744	1	0.2894	0.2838	0.2650	0.2594
LMIR	0.9537	6	0.3256	3	0.8214	7	0.9531	0.9037	0.7390	0.6896
NGFO	0.9662	7	0.3251	2	0.8279	10	0.9482	0.9031	0.7527	0.7076
FRVR	0.8624	4	0.3328	8	0.7416	4	0.9459	0.8693	0.6139	0.5373
ALTK	0.9663	8	0.3299	5	0.8269	9	0.9574	0.9085	0.7453	0.6963
ALMR	0.9503	5	0.3341	9	0.8156	6	0.9662	0.9097	0.7215	0.6650
ALIR	1.0617	13	0.4309	13	0.8907	13	1.1230	1.0359	0.7456	0.6585
BAHN	0.9961	11	0.3471	11	0.8393	11	0.9559	0.9122	0.7665	0.7227
MSMI	1.5769	14	0.7399	14	2.4661	14	3.2986	2.9864	1.9457	1.6335
NALM	0.9730	10	0.3250	1	0.8265	8	0.9427	0.8991	0.7539	0.7103
KSIM	0.7550	1	0.3448	10	0.5926	2	0.8450	0.7504	0.4348	0.3401

Table 17. Ranking of companies in Pharmaceutical & Medicinal Products industry

Company	S_i	Rank	R_i	Rank	v =0.5 Q_i	Rank	v =0.1 Q_i	v =0.25 Q_i	v =0.75 Q_i	v =0.9 Q_i
DLGM	1.1429	16	0.2550	8	1.1863	14	1.2424	1.2213	1.1513	1.1302
ABDI	1.0113	8	0.2548	7	1.0915	10	1.3305	1.2409	0.9422	0.8526
DALZ	1.0985	13	0.2722	14	1.2007	15	1.4004	1.3255	1.0758	1.0009
IRDR	1.2004	19	0.2718	13	1.3299	19	1.4139	1.3824	1.2775	1.2460
PDRO	0.7880	1	0.2058	2	0.1824	1	0.1888	0.1864	0.1784	0.1760
THDP	1.0678	11	0.2660	11	1.1652	13	1.3346	1.2710	1.0594	0.9958
THSH	1.0592	10	0.2430	4	0.9065	6	0.9408	0.9279	0.8851	0.8722
DABO	1.0849	12	0.2515	6	1.1112	11	1.2328	1.1872	1.0352	0.9896

DOSE	0.9141	3	0.2459	5	0.8765	4	1.1161	1.0262	0.7267	0.6368
AMIN	1.1757	18	0.2655	10	1.2767	17	1.3659	1.3324	1.2210	1.1875
EXIR	0.8496	2	0.2730	15	0.8953	5	1.3068	1.1525	0.6381	0.4838
DAML	1.1704	17	0.2671	12	1.2971	18	1.3911	1.3558	1.2384	1.2031
DAML	1.1343	15	0.2924	17	1.1366	12	1.2676	1.2185	1.0548	1.0057
DFRB	0.9345	5	0.2867	16	1.0844	9	1.4572	1.3174	0.8513	0.7115
ALBZ	0.9277	4	0.3762	19	1.0450	8	1.5192	1.3414	0.7486	0.5707
DSIN	1.1152	14	0.3039	18	1.2275	16	1.5120	1.4053	1.0497	0.9430
FTIR	1.0581	9	0.2139	3	0.8271	3	0.7494	0.7785	0.8756	0.9048
DPAK	0.9769	7	0.2605	9	1.0375	7	1.3300	1.2203	0.8547	0.7450
KIMI	0.9398	6	0.2034	1	0.6530	2	0.6696	0.6634	0.6427	0.6364

In Table 17 the best ranked company is PDRO when v =0.5. This company is proposed as a compromise solution in other values of v.

5. Conclusions

In today’s competitive world economy, companies should focus on the maximization of shareholder value. For this aim they need to ensure that all activities yield positive net present value. On the other hand, comprehensive financial ratios also provide useful quantitative information about performance of a company. However, many studies in the field use only traditional ratios.

To overcome these shortcomings, the integrated fuzzy MCDM approach is proposed. It is proposed to use both of accounting measures and economic value measures for financial performance evaluation of companies simultaneously in the current research. Also, the inner dependence among financial measures is considered and it is proposed to weight them by using fuzzy ANP. Based on an analytic structure of the problem, at first FANP is used to determine the weights of the main criteria and sub-criteria. Then fuzzy VIKOR is successfully applied for ranking the companies based on their financial performance.

A case study for evaluating of 143 Iranian manufacturing companies in 14 related industries is presented. Companies are ranked based on approved official data from TSE database in ten year period.

The results of the research in line with calculated relative significances showed that in order to achieve better performance evaluation, companies should pay the most attention to Market Value Added (MVA) measures, also to REVA, CVA, EVA and TVA sub-criteria from Economic value criteria group. The most important sub-criterion from accounting measures criteria, influencing the total performance of the company, is Operating Profit Growth (OPG).

In the future the research could be extended including some other financial performance measures like shareholder value added, equity economic value added, etc. Considering interrelations between criteria, DANP (DEMATEL based ANP), for calculating the weights of criteria can be used in further study too.

REFERENCES

[1] **Amado, C. A. F., Santos, S. P., Marques, P. M. (2012),** ***Integrating the Data Envelopment Analysis and the Balanced Scorecard Approach for Enhanced Performance Assessment.*** *Omega* 40(3), 390–403;

[2] **Antucheviciene, J., Zakarevicius, A., Zavadskas, E. K. (2011),** ***Measuring Congruence of Ranking Results Applying Particular MCDM Methods.*** *Informatica* 22(3), 319–338;

[3] **Antucheviciene, J., Zavadskas, E. K., Zakarevicius, A. (2012),** ***Ranking Redevelopment Decisions of Derelict Buildings and Analysis of Ranking Results.*** *Economic Computation and Economic Cybernetics Studies and Research* 46(2), 37–62, *ASE Publishing*;

[4] **Balezentis, A., Balezentis, T., Misiunas, A. (2012),** ***An Integrated Assessment of Lithuanian Economic Sectors Based on Financial Ratios and Fuzzy MCDM Methods.*** *Technological and Economic Development of Economy* 18(1), 34–53;

[5] **Bayrakdaroglu, A., Yalcin, N. (2012),** ***Strategic Financial Performance Evaluation of the Turkish Companies Traded on ISE.*** *Ege Academic Review* 12(4), 529–539;

[6] **Chang, D. Y. (1996),** ***Applications of the Extent Analysis Method on Fuzzy AHP.*** *European Journal of Operational Research* 95, 649–655;

[7] **Cheng, C. H., Chen, C. T., Huang, S. F. (2012),** ***Combining Fuzzy Integral with Order Weight Average (OWA) Method for Evaluating Financial Performance in the Semiconductor Industry.*** *African Journal of Business Management* 6(21), 6358–6368;

[8] **Chou, W. C., Cheng, Y. P. (2012),** ***A Hybrid Fuzzy MCDM Approach for Evaluating Website Quality of Professional Accounting Firms.*** *Expert Systems with Applications* 39(3), 2783–2793;

[9] **Ergul, N., Seyfullahogullari, C. A. (2012),** ***The Ranking of Retail Companies Trading in ISE.*** *European Journal of Scientific Research* 70(1), 29–37;

[10] **Esbouei, S. K., Ghadikolaei, A. S. (2013),** ***An Integrated Approach Based on FAHP and ARAS Methods for Financial Performance Evaluation.*** *ARPN Journal of systems and software* 3(4), 53–56;

[11] **Ghadikolaei, A. S., Esbouei, S. K. (2014),** ***Integrating Fuzzy AHP and Fuzzy ARAS for Evaluating Financial Performance.*** *Boletim da Sociedade Paranaense de Matemática* 32(2), 163–174;

[12] **Ghadikolaei, A. S., Esbouei, S. K., Antucheviciene, J. (2014),** ***Applying Fuzzy MCDM for Financial Performance Evaluation of Iranian Companies.*** *Technological and Economic Development of Economy* 20(2), *in press*, pages 274-291;

[13] **Hajiabasi, M., Kaviani, M., Samadi Largani, N., Samadi Largani, M., Montazeri, H. (2012),** ***Comparison of Information Content Value Creation***

Measures (EVA, REVA, MVA, SVA, CSV and CVA) and Accounting Measures (ROA, ROE, EPS, CFO) in Predicting the Shareholder Return (SR) Evidence from Iran Stock Exchange. *ARPN Journal of Science and Technology* 2(5), 517–521;

[14] **Ignatius, J., Behzadian, M., Malekan, H. S., Lalitha, D. (2012),** ***Financial Performance of Iran's Automotive Sector Based on PROMETHEE II.*** *Proceedings of the 2012 IEEE ICMIT*, 35–38;

[15] **Jones, J. S., Miller, S. A., Yeager, T. J. (2011),** ***Charter value, Tobin's Q and Bank Risk during the Subprime Financial Crisis.*** *Journal of Economics and Business* 63(5), 372–391;

[16] **Kaplinski, O., Tupenaitė, L. (2011),** ***Review of the Multiple Criteria Decision Making Methods, Intelligent and Biometric Systems Applied in Modern Construction Economics.*** *Transformations in Business & Economics* 10(1), 166–181;

[17] **Kung, J.Y., Chuang, T. N., Ky, C. M. (2011),** ***A Fuzzy MCDM Method to Select the Best Company Based on Financial Report Analysis.*** *IEEE International Conference on Fuzzy Systems*, June 27–30, Taipei, 2013–2017;

[18] **Largani, M. S., Kaviani, M., Abdollahpour, A. (2012),** ***A Review of the Application of the Concept of Shareholder Value Added (SVA) in Financial Decisions.*** *Procedia - Social and Behavioural Sciences* 40: 490–497;

[19] **Lee, P. T. W., Lin, C. W., Shin, S. H. (2012),** ***A Comparative Study on Financial Positions of Shipping Companies in Taiwan and Korea Using Entropy and Grey Relation Analysis.*** *Expert Systems with Applications* 39(5), 5649–5657;

[20] **Lin, H. F. (2010),** ***An Application of Fuzzy AHP for Evaluating Course Website Quality.*** *Computers & Education* 54(4), 877–888;

[21] **Liou, J. J. H., Tzeng, G.-H. (2012),** ***Comments on "Multiple Criteria Decision Making (MCDM) Methods in Economics: an overview".*** *Technological and Economic Development of Economy* 18(4), 672–695;

[22] **Opricovic, S., Tzeng, G. H. (2004),** ***Compromise Solution by MCDM Methods: A comparative analysis of VIKOR and TOPSIS.*** *European Journal of Operational Research* 156(2), 445–455;

[23] **Saaty, T.L. (1996),** ***Decision Making with Dependence and Feedback: The Analytic Network Process***. Pittsburgh: RWS Publications;

[24] **Saaty, T. L. (2003),** ***Decision-making with the AHP: Why is the Principal Eigenvector Necessary.*** *European Journal of Operational Research* 145(1), 85–91;

[25] **Secme, N. Y., Bayrakderaglu, A., Kahraman, C. (2009),** ***Fuzzy Performance Evaluation in Turkish Banking Sector Using Analytic Hierarchy Process and TOPSIS.*** *Expert Systems with Applications* 36, 11699–11709;

[26] **Venanzi, D. (2012), *Financial Performance Measures and Value Creation: The State of the Art.*** Springer Briefs in Business;

[27] **Vinodh, S., Varadharajan, A. R., Subramanian, A. (2013), *Application of Fuzzy VIKOR for Concept Selection in an Agile Environment.*** *The International Journal of Advanced Manufacturing Technology* 65(5–8), 825–832;

[28] **Wang, Y. J., Lee, H. S. (2010), *Evaluating Financial Performance of Taiwan Container Shipping Companies by Strength and Weakness Indices.*** *International Journal of Computer Mathematics* 87(1), 38–52;

[29] **Yalcin, N., Bayrakdaraglu, A., Kahraman, C. (2012), *Application of Fuzzy Multi-criteria Decision Making Methods for Financial Performance Evaluation of Turkish Manufacturing Industries*.** *Expert Systems with Applications* 39(1), 350–364;

[30] **Zavadskas, E. K., Turskis, Z. (2011), *Multiple Criteria Decision Making (MCDM) Methods in Economics.*** *Technological and Economic Development of Economy* 17(2), 397–427.