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Financial Performance Evaluation of Turkish Energy Companies with Fuzzy AHP and Fuzzy TOPSIS Methods

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Abstract: *Turkey's economy has expanded in recent years with the increase in energy consumption. Energy is a key input in production and plays a crucial role in the development of an economy. Energy sector interacts with other sectors hence the performances of energy firms are inevitable to follow-up. In the study thirteen energy firms are evaluated with 5 main and 15 sub-criteria for the period of 2008-2013. The 15 sub-criteria are classified in the following main criteria: liquidity, activity, financial leverage, profitability and growth ratios. The weights of the ratios are determined by Fuzzy AHP and then Fuzzy TOPSIS method is used for the rankings of the energy firms. Traditional multi-criteria decision making methods are not used in this study, due to the fact that they are insufficient under uncertainty. After 2008 global financial crisis, the uncertainty has increased all over the world hence the usage of fuzzy methods can provide better results under these conditions. Findings show that Avrasya Oil, Turcas and Aksu have the highest ranking.*

Keywords: Performance Evaluation, Fuzzy AHP, Fuzzy TOPSIS, Energy Sector, Multi-Criteria Decision Making

JEL Classification: L61, G11, Q40

1. Introduction

Energy is one of the most important parts of economic and social development. In addition, it is indispensable and non-substitutable in numerous fields of daily life. The importance of energy is increasing day by day in consequence of rapid development in technology, population growth and increase in life standards in the public life. Net growth of the consumption of energy is actualized by developing economies. Turkey has an increasing population with its developing economy. It performs transformation from agriculture to industry in contrast to developed economies and it also takes part in the most rapid developing energy markets. While the global energy needs which increases with the amount of %2 in a year, it is at %6-%8 level that 3-4 times more than world average energy need in Turkey (dogaka.gov.tr). From this point, in developing economies like Turkey, energy sectors have important structural links with other sectors of economy. Following the developments of these sectors which provide substantially input to other sector of economy is quite important. Profitability which is one of the main purposes of firms has more importance in competitive business environment. It is the fact that the high performing firms will exist in this competition environment. The performance of these firms will be important not only for their subsistence but also for investors, creditors and economy of the country.

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In this sense, it is inevitable to evaluate the performances of the energy firms. Financial ratios are widely used for evaluating a firm's performance and financial situation. The performance evaluation of a firm helps investors to make investment decisions as well as gives information about the firms. In the literature, researchers have used various multi-criteria decision making models (MCDM) for the performance evaluation in different sectors. For instance, Feng and Wang (2000); Wang (2008) carried out TOPSIS and Fuzzy TOPSIS methods for the performance evaluation in aviation, Yurdakul and İç (2003) used TOPSIS method in automotive sectors respectively. Chou and Liang (2001) used AHP in shipping, Xia and Wu (2007); Chamodrakas and Martakos (2010) utilized AHP and Fuzzy AHP for supplier selection respectively. Also Yalçın, Bayraktaroğlu and Kahraman (2012) used Fuzzy AHP, VIKOR and TOPSIS methods in manufacturing sector. Fuzzy AHP and TOPSIS are carried out in performance evaluation of airports (Chang, Cheng & Wang, 2003); cement firms (Ertuğrul & Karakasoğlu, 2009) and banks (Mandic, Delibasic, Knezevic & Benkovic, 2014; Mahrooz, Maedeh & Morteza, 2013; Seçme, Bayraktaroğlu & Kahraman, 2009). Fuzzy AHP (Weifeng & Huihuan, 2008) and Fuzzy TOPSIS methods are also used in banking (Akkoç & Vatansever, 2013). Sun (2010) also utilized Fuzzy AHP and Fuzzy TOPSIS methods for computer companies. Kalogeras, Baourakis, Zopounidis and Van Dijk (2005) employed PROMETHEE for food firms. Ignatius, Behzadian, Malekan and Lalitha (2012) used PROMETHEE II for the performance evaluation of the automotive firms. Erginel and Sentürk (2011) carried out Fuzzy ANP for the ranking of GSM operators. For the energy firms Ergül (2010) and Sakarya, Yıldırım and Akkuş (2015) used TOPSIS method.

As it is seen there are few studies in the literature that Fuzzy AHP and Fuzzy TOPSIS methods are integrated for the performance evaluation of energy firms. In the study, we evaluate the financial performances of energy firms for the period of 2008-2013 with utilizing the Fuzzy AHP and Fuzzy TOPSIS methods. The weights of the criteria are determined by Fuzzy AHP method and then Fuzzy TOPSIS method is used for the rankings of the energy firms. Traditional multi-criteria decision making methods are not used in this study, due to the fact that they are insufficient under uncertainty. After 2008 global crisis, the uncertainty has increased all over the world hence the usage of fuzzy methods can provide better results under these conditions. This study will contribute to literature in terms of present the general outlook of Turkish energy sector after the 2008 global crisis and will give chance to investors and creditors to evaluate the performance of firms.

In this study, we use the financial data of 13 energy firms traded in Borsa Istanbul. The dataset consists of 15 sub-criteria which are classified in the following main criteria: liquidity, activity, financial leverage, profitability and growth ratios. The rest of the paper is organized as follows. Section 2 explains the fuzzy sets, Fuzzy AHP and Fuzzy TOPSIS methods which are used in the study. Section 3 describes the data presents the empirical findings and Section 4 concludes and suggests for the future studies.

2. Fuzzy Sets

The classical set theory is built on the concept of "set" of which a variable is either a member or not (Chen & Pham, 2000: 1). In classical logic, variables are defined as true or false, black or white, 0 or 1 (Kartalopoulos, 1995: 5). Thus the real world applications are complex and it is hard to describe with crisp numbers.

Fuzzy set theory was investigated in the 1920's and 1930's by Lukasiewicz and Tarski (Pelletier, 2000: 343), but it is first introduced by Zadeh in 1965 to deal with the uncertainty due to imprecision and vagueness (Tanaka, 1997: 1; Chen, Yizeng, Jian & Yuanyuan, 2016: 16). Fuzzy set theory is an important tool to reinforce the comprehensiveness and moderateness of the decision making process (Seçme et al., 2009: 11701). Fuzzy set is a special class of objects which is defined by a membership function (Kumar, Shankar & Debnath, 2015: 449). A tilde '~' is used above a letter in the function when it presents fuzzy set. In the literature the most widely used fuzzy numbers are triangular and trapezoidal numbers. In this study triangular fuzzy numbers (TFNs) are used to consider the fuzziness of measurements and evaluations. A TFN, $\tilde{M}$ on R is provided by its membership function $\mu_{\tilde{M}}(x): U \subseteq R \rightarrow [0,1]$ which is linear piecewise continuous as (Kamvysi, Gotzamani, Andronikidis & Georgiou, 2014: 1087):

$$\mu_{\tilde{M}}(x) = \begin{cases} \frac{x}{m-l} - \frac{l}{m-l} & , x \in [l, m] \\ \frac{u}{u-m} - \frac{x}{u-m} & , x \in [m, u] \\ 0 & , otherwise \end{cases} \quad (1)$$

If $M_1 = (l_1, m_1, u_1)$ and $M_2 = (l_2, m_2, u_2)$ and then the operational laws of addition, multiplication, reciprocal and division for these two TFN can be presented as follows:

$$M_1 \oplus M_2 = (l_1, m_1, u_1) \oplus (l_2, m_2, u_2) = (l_1 + l_2, m_1 + m_2, u_1 + u_2)$$

$$M_1 \otimes M_2 = (l_1, m_1, u_1) \otimes (l_2, m_2, u_2) \approx (l_1 \times l_2, m_1 \times m_2, u_1 \times u_2) \quad (2)$$

$$M_1^{-1} = (l_1, m_1, u_1)^{-1} = (1/u_1, 1/m_1, 1/l_1)$$

$$M_1 (/) M_2 \approx (l_1 / u_2, m_1 / m_2, u_1 / l_2)$$

The linguistic variables and fuzzy ratings for the criteria are shown in Table 1.

Table 1. Linguistic Terms For Criteria Ratings

Linguistic terms	Fuzzy numbers	Membership function	Domain	Triangular Fuzzy Scale
Just Equal				(1,1,1)
Equal Importance	$\tilde{1}$	$\mu_M(x)=(3-x)/(3-1)$	$1 \le x \le 3$	(1,1,3)
Weak Importance	$\tilde{3}$	$\mu_M(x)=(x-1)/(3-1)$	$1 \le x \le 3$	(1,3,5)
		$\mu_M(x)=(5-x)/(5-3)$	$3 \le x \le 5$	
Strong Importance	$\tilde{5}$	$\mu_M(x)=(x-3)/(5-3)$	$3 \le x \le 5$	(3,5,7)
		$\mu_M(x)=(7-x)/(7-5)$	$5 \le x \le 7$	
Very Strong Importance	$\tilde{7}$	$\mu_M(x)=(x-5)/(7-5)$	$5 \le x \le 7$	(5,7,9)
		$\mu_M(x)=(9-x)/(9-7)$	$7 \le x \le 9$	
Extremely Preferred	$\tilde{9}$	$\mu_M(x)=(x-7)/(9-7)$	$7 \le x \le 9$	(7,9,9)

2.1. Fuzzy AHP Method

Analytical Hierarchy Process (AHP) is an approach that was developed by Saaty (1990) which involves structured multi-criteria into a hierarchy, assessing the importance of these criteria, comparing the alternatives for each criterion and determining the ranking of the alternatives (Hu & Peng, 2008: 1095). AHP is a mathematical decision making technique that takes into consideration of both qualitative and quantitative ways of decisions and it increases the basic decisions by the aspect of reducing complex decisions (Punniyamoorty, Ponnusamy & Lakshmi, 2012: 81). AHP is a useful method utilizing subjective determinations for solving complex decision making problems (Lin, 2010: 881).

In general, incomplete and uncertain data information could be introduced to decision making problems. Also the decisions made by the experts depend on subjective thoughts; therefore it is more suitable to use fuzzy numbers instead of crisp numbers (Gu & Zhu, 2006: 401). The fuzzy AHP method reflects decision maker's appraisal of fuzziness and vagueness when making pairwise comparisons of criteria and alternatives (Lee et al., 2010: 2238). In literature, Fuzzy AHP is regularly used in supplier selection problems (Bronja & Bronja, 2015; Sultana, Ahmed & Azeem, 2015; Rezaei, 2014; Kılınçcı & Önal, 2011; Chamodrakas & Martakos, 2010; Xia & Wu, 2007). Fuzzy AHP is also used in different fields by following researchers: Beşkese, Demir, Özcan and Ökten (2015) in the landfill site selection; Nguyen et al. (2015) in the selection of machine tools; Belgin (2015) in optimization of multi objective simulation system. In addition Mangla, Kumar and Mukesh (2015) evaluated risk analysis in green supply chain; Chen, Hsieh and Do (2015) examined teaching performance; Kumar (2015) analyzed customer preferences; Isaai, Kanani, Tootoonchi and Afzali (2011) examined intelligent timetable with Fuzzy AHP method.

In this study, we use Chang (1996)'s extended analysis to evaluate the weights of the criteria. Chang's extended analysis consists of the following steps (Chang, 1996: 649; Büyüközkan, Kahraman & Ruan, 2004: 262; Mosadeghi, Warnken, Tomlinsen & Mirfenderesk, 2015: 58):

Step 1: Let X = {$x_1, x_2, \dots, x_n$} be an object set and U= {$u_1, u_2, \dots, u_m$} be a goal set. Accourding to extent analysis, the method can be performed with respect to each object for each goal resulting in m extent analysis values for each object, given as $M_{gi}^1, M_{gi}^2, \dots, M_{gi}^m$, $i = 1, 2, \dots, n$, where all M_{gi}^j ($j = 1, 2, \dots, m$) are triangular fuzzy numbers representing the performance of the object with regard to each goal u_j. The values of fuzzy extensions for *i*-th object are given in Equation (3);

$$S_i = \sum_{j=1}^{m} M_{gi}^j \otimes \left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1} \quad (3)$$

In order to obtain the equation $\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1}$, it is necessary to perform additional fuzzy operations with *m* values of the extended analysis, which is represented in Equation (4) and (5);

$$\sum_{j=1}^{m} M_{gi}^j = \left(\sum_{j=1}^{m} l_j, \sum_{j=1}^{m} m_j, \sum_{j=1}^{m} u_j \right) \quad (4)$$

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right] = \left(\sum_{i=1}^{n} l_i, \sum_{i=1}^{n} m_i, \sum_{i=1}^{n} u_i \right) \quad (5)$$

It is necessary to calculate the inverse vector using Equation (6);

$$\left[\sum_{i=1}^{n} \sum_{j=1}^{m} M_{gi}^j \right]^{-1} = \left(\frac{1}{\sum_{i=1}^{n} u_i}, \frac{1}{\sum_{i=1}^{n} m_i}, \frac{1}{\sum_{i=1}^{n} l_i} \right) \quad (6)$$

Step 2: The degree of possibility for M_2 is defined as:

$$V(M_2 \geq M_1) = \sup_{y \geq x} \left[\min(\mu_{M_1}(x), \mu_{M_2}(y)) \right] \quad (7)$$

It can be represented in the following manner by Equation (7);

$$V(M_2 \geq M_1) = hgt(M_2 \cap M_1)\ \mu_{M2}(d) \quad (8)$$

$$= \begin{cases} 1, & if \quad m_2 \geq m_1 \\ 0, & if \quad l_1 \geq u_2 \\ \dfrac{l_1 - u_2}{(m_2 - u_2) - (m_1 - l_1)}, & otherwise \end{cases} \tag{9}$$

where *d* is the ordinate of the highest intersection point between μM_1 and μM_2. We need both the values of $V(M_2 \geq M_1)$ and $V(M_1 \geq M_2)$ to compare μM_1 and μM_2.

Step 3: The degree of possibility of fuzzy number M_i (i=1,2,...,k) can be defined by Equation (10);

$$\begin{aligned} &V(M \geq M_1, M_2, \ldots, M_k) \\ &= V[(M \geq M_1) \text{ and } (M \geq M_2) \text{ i } \ldots \text{ i } (M \geq M_k)] \\ &= \min V(M \geq M_i),\ i=1,2,3 \end{aligned} \tag{10}$$

Let assume that Equation (11);

$$d'(Ai) = \min V(S_i \geq S_k) \tag{11}$$

for k=1,2,...,n; $k \neq i$. The weight vector is obtained by Equation (12);

$$W' = (d'(A_1), d'(A_2), \ldots, d'(A_n))^T \tag{12}$$

where, A_i (i =1,2,...,n) consists of n elements.

Step 4: Through normalization, the weight vectors are reduced to Equation (13);

$$W = (d(A_1), d(A_2), \ldots, d(A_n))^T \tag{13}$$

where W represents a non-fuzzy number.

2.2. Fuzzy TOPSIS Method

TOPSIS, which is developed by Hwang and Yoon (1981), is a multi-attribute decision making method to identify solutions from a finite set of alternatives (Li, 2009: 220). In the classical TOPSIS method, the ratings of alternatives are presented by real values. However it is difficult to determine the values of ratings of the alternatives with respect to local criteria, these ratings are presented by fuzzy values (Dymova, Sevastjanov & Tikhonenko, 2015: 117). In TOPSIS, it is important to define positive ideal solution (PIS) and negative ideal solution (NIS). The ideal solution composed of best attribute values, whereas the negative ideal solution is comprised of all worst attribute values (Yue, 2013: 112). The alternatives are compared with these PIS and NIS, to find out the distance (Viswanadham & Samvedi, 2013: 6490). The PIS is the solution that maximizes the benefit criteria and minimizes the cost criteria; whereas the NIS maximizes the cost criteria and minimizes the benefit criteria (Lee, Chiang & Chen, 2012: 40). The best alternative should have the shortest distance from the PIS and the farthest distance from NIS.

In TOPSIS method the ratings of alternatives are crisp values, however due to vagueness of the decision data, crisp data are ineligible to model real life decision problems (Lee et al., 2012: 41). In this paper, we adopt the extension of TOPSIS method introduced by Chen (2000), to achieve the ranking of the alternatives in fuzzy environment. The fuzzy TOPSIS calculation steps are given as follows (Song, Ming, Wu & Zhu, 2013: 1176; Viswanadham & Samvedi, 2013: 6491):

Step 1: Creating the Decision Matrix: Firstly aggregated ratings are calculated using Equation (14):

$$\tilde{X}_{ij} = \frac{1}{s}\left[\tilde{x}_{ij}^{1} \oplus \tilde{x}_{ij}^{2} \oplus \ldots \tilde{x}_{ij}^{s}\right] \tag{14}$$

where $\tilde{x}_{ij}^{s}$ is the performance rating value obtained from s-th decision maker. The fuzzy decision matrix is created using Equation (15):

$$D = \begin{bmatrix} \tilde{x}_{11} \cdots \tilde{x}_{1j} \cdots \tilde{x}_{1n} \\ \vdots \quad \vdots \quad \vdots \\ \tilde{x}_{i1} \cdots \tilde{x}_{ij} \cdots \tilde{x}_{in} \\ \vdots \quad \vdots \quad \vdots \\ \tilde{x}_{m1} \cdots \tilde{x}_{mj} \cdots \tilde{x}_{mn} \end{bmatrix} \quad \text{where } \tilde{x}_{ij} = (a_{ij}, b_{ij}, c_{ij}) \tag{15}$$

Step 2: Normalizing the Decision Matrix: The normalized fuzzy matrix is shown by $\tilde{R} = \left[\tilde{r}_{ij}\right]_{mxn}$. B represents benefit criteria and C represents cost criteria.

$$\begin{aligned} r_{ij} &= \left(\frac{a_{ij}}{c_j^*}, \frac{b_{ij}}{c_j^*}, \frac{c_{ij}}{c_j^*}\right), \quad j \in B \\ r_{ij} &= \left(\frac{a_j^-}{c_{ij}}, \frac{a_j^-}{b_{ij}}, \frac{a_j^-}{a_{ij}}\right), \quad j \in C \\ c_j^* &= \max_i c_{ij}, \quad if \ j \in B \\ a_j^- &= \min_i a_{ij}, \quad if \ j \in C \end{aligned} \tag{16}$$

After normalization, the fuzzy elements take the values between [0,1].

Step 3: Calculating the Weighted Normalized Fuzzy Decision Matrix: The weighted normalized decision matrix is shown as $\tilde{V} = \left[\tilde{v}_{ij}\right]_{mxn}$;

$$\tilde{v}_{ij} = \tilde{r}_{ij} \otimes w_j, \quad i = 1,2,\ldots,m, \text{ and } j = 1,2,\ldots,n \tag{17}$$

Step 4: Calculating the Positive and Negative Ideal Solutions: Fuzzy Positive Ideal Solution (FPIS) and Fuzzy Negative Ideal Solution (FNIS) can be given as:

$$\begin{aligned} A^* &= \left(\tilde{v}_1^*, \tilde{v}_2^*, \ldots, \tilde{v}_n^*\right) \\ A^- &= \left(\tilde{v}_1^-, \tilde{v}_2^-, \ldots, \tilde{v}_n^-\right) \end{aligned} \tag{18}$$

where $v_j^* = (1,1,1), v_j^- = (0,0,0) \, and \ j = 1,2,\ldots,n$

Step 5: Calculating the Distances from FPIS and FNIS: By Equations (19) and (20), the distances from FPIS and FNIS are calculated.

$$d_i^* = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^*\right), \quad i = 1, 2, \ldots, m \tag{19}$$

$$d_i^- = \sum_{j=1}^{n} d\left(\tilde{v}_{ij}, \tilde{v}_j^-\right),\ i = 1, 2, \ldots, m \tag{20}$$

The distance between two triangular fuzzy numbers $\tilde{a} = (a_1, a_2, a_3)$ and $\tilde{b} = (b_1, b_2, b_3)$ is calculated by Equation (21):

$$d\left(\tilde{a}, \tilde{b}\right) = \sqrt{\frac{1}{3}\left[(a_1 - b_1)^2 + (a_2 - b_2)^2 + (a_3 - b_3)^2\right]} \tag{21}$$

Step 6: Computing the Closeness Coefficients: Closeness coefficients of each alternative are computed by Equation (22):

$$CC_i = \frac{d_i^-}{d_i^* + d_i^-},\ i = 1, 2, \ldots, m \tag{22}$$

If CC_i value of the alternative is close to 1, then the alternative is closer to FPIS and farther from the FNIS.

3. Data and Findings

The purpose of the study is to evaluate the financial performances of Turkish energy firms during the period 2008-2013. All the financial ratios are calculated with the help of financial statements of the firms. The sample consists of thirteen energy firms. These are Akenerji (AKENR), Aksa (AKSEN), Aksu (AKSUE), Anel Electric (ANELE), Avrasya Oil (AVTUR), Ayen Energy (AYEN), Aygaz (AYGAZ), Emek Electric (EMKEL), Gersan Electric (GEREL), Ipek Dogal Energy (IPEKE), Petkim (PETKM), Turcas (TRCAS), Tupras (TUPRS) and Zorlu Energy (ZOREN). The financial performance of energy firms are evaluated with 5 main and 15 sub-criteria. These performance criteria are indicated in Table 2.

Table 2. Used Performance Criteria

Main Criteria	Code	Formula Sub-Criteria	Ratio
Growth Ratios	(GR)	$[(S_t - S_{t-1}) / S_{t-1})]*100$[1]	Sales Growth
		$[(A_t - A_{t-1}) / A_{t-1})]*100$[2]	Assets Growth
		$[(E_t - E_{t-1}) / E_{t-1})]*100$[3]	Shareholders' Equity Growth
Activity Ratios	(AR)	Total Net Sales/Accounts Receivables	Accounts Receivable Turnover
		Sales/Fixed Assets	Fixed Assets Turnover
		Sales/Total Equity	Equity Turnover
		Sales/Total Assets	Total Assets Turnover
Financial Leverage Ratios	(FLR)	Total Debt/Total Assets	Debt Ratio
		Total Debt/ Total Equity	Debt To Equity Ratio
Profitability Ratios	(PR)	Net income(loss)/Total Assets	Return On Assets (ROA)
		Net income(loss)/Total Equity	Return On Equity (ROE)
		Net income(loss)/ Sales	Net Profit Margin
Liquidity Ratios	(LR)	Current Assets/Current Liabilities	Current Ratio
		Quick Assets/Current Liabilities	Quick Ratio
		Cash and Cash Equivalent Assets/Current	Cash Ratio

The weights of the criteria are determined by using Fuzzy AHP. Four decision makers from different areas (creditor, shareholder, academic and a sector employee) are selected to represent the different expectations of stakeholders to evaluate the importance of financial ratios with the help of pairwise comparisons. Fuzzy AHP is proposed to take the decision makers subjective judgments into consideration and to reduce the uncertainty and vagueness in the decision process (Ertuğrul & Karakaşoglu, 2009: 706).

The weights of the criteria are first determined by using Fuzzy AHP. The pairwise comparison scores were examined by four decision makers. Thus decision makers' pair-wise comparison scores are transformed into triangular fuzzy numbers as in Table 3.

Table 3. Fuzzy Pairwise Comparison Matrix

	GR	AR	FLR	PR	LR
GR	(1,1,1)	(1,1,3)	(1,1,3)	(0.143,0.2,0.333)	(0.2,0.333,1)
AR	(0.333,1,1)	(1,1,1)	(1,1,3)	(0.2,0.333,1)	(0.2,0.333,1)
FLR	(0.333,1,1)	(0.143,0.2,0.333)	(1,1,1)	(0.2,0.333,1)	(0.2,0.333,1)
PR	(3,5,7)	(1,3,5)	(1,3,5)	(1,1,1)	(1,3,5)
LR	(1,3,5)	(1,3,5)	(1,3,5)	(0.2,0.333,1)	(1,1,1)

After creating fuzzy pairwise comparison matrix, weights of all criteria and sub-criteria are assessed by the help of Fuzzy AHP. According to the Fuzzy AHP method, firstly synthetic values must be calculated. The synthetic values for each criterion are calculated by Equation (3);

$$S1= (3.343,3.533,4.333) \otimes (0.017,0.028,0.052) = (0.056,0.1,0.435)$$

$$S2= (2.733,3.667,7) \otimes (0.018,0.028,0.050) = (0.046,0.104,0.365)$$

$$S3= (1.876,2.867,4.333) \otimes (0.018,0.028,0.050) = (0.031,0.081,0.226)$$

$$S4= (7,15,23) \otimes (0.018,0.028,0.050) = (0.117,0.424,1.201)$$

$$S5= (4.2,10.333,17) \otimes (0.018,0.028,0.050) = (0.07,0.292,0.888)$$

The synthetic values are compared by using Equation (8) and (9);

$V(S1 \geq S2) = 1$, $V(S1 \geq S4) = 0.495$ $V(S1 \geq S3) = 1$, $V(S1 \geq S5) = 1$

$V(S2 \geq S1) = 1$, $V(S2 \geq S4) = 0.437$ $V(S2 \geq S3) = 1$ $V(S2 \geq S5) = 1$

$V(S3 \geq S1) = 1$, $V(S3 \geq S4) = 0.443$ $V(S3 \geq S2) = 1$, $V(S3 \geq S5) = 1$

$V(S4 \geq S1) = 1$, $V(S4 \geq S3) = 1$ $V(S4 \geq S2) = 1$, $V(S4 \geq S5) = 1$

$V(S5 \geq S1) = 1$, $V(S5 \geq S3) = 1$ $V(S5 \geq S2) = 1$, $V(S5 \geq S4) = 1$

Then the priority weights are calculated by using Equation (11);

$d'(S_1)= \min (1, 1, 0.495, 1) = 0.495$

$d'(S_2)= \min (1, 1, 0.437, 1) = 0.437$

$d'(S_3)= \min (1, 1, 0.443, 1) = 0.443$

$d'(S_4)= \min (1, 1, 1, 1) = 1$

$d'(S_5)= \min (1, 1, 1, 1) = 1$

Priority weights form $W' = (0.495, 0.437, 0.443, 1, 1)^T$ vector. After the normalization, the weight vector for the main criteria is calculated as (0.1467, 0.1294, 0.1314, 0.2963, 0.2963). Then, weights of sub-criteria are calculated similarly[4]. After formulations the weights of the financial ratios are reported in Table 4.

Table 4. Weights of Main and Sub-Criteria

Main Criteria	Weights	Sub-Criteria	Weights
Growth Ratios	0.1467	Sales Growth	0.071
		Assets Growth	0.071
		Shareholders' Equity Growth	0.004
Activity Ratios	0.1294	Accounts Receivable Turnover	0.051
		Equity Turnover	0.051
		Fixed Assets Turnover	0.015
		Total Assets Turnover	0.012
Leverage Ratios	0.1314	Debt Ratio	0.066
		Debt To Equity Ratio	0.066
Profitability Ratios	0.2963	Return On Equity (ROE)	0.099
		Return On Assets (ROA)	0.099
		Net Profit Margin	0.099
Liquidity Ratios	0.2963	Current Ratio	0.142
		Quick Ratio	0.142
		Cash Ratio	0.013

As can be seen from the Table 4 it can be concluded that in the process of financial performance evaluation of the Turkish energy firms, the main criteria of liquidity and profitability ratios are the most important with same weights (0.2963), followed by the criteria of growth ratio (0.1467), financial leverage ratio (0.1314) and the activity ratio (0.1294) respectively. In addition it is determined that the most important sub-criteria are current and quick ratios (0.142) followed by ROA, ROE and net profit margin ratios (0.099).

Then Fuzzy TOPSIS method is used for the ranking of thirteen energy firms according to the relative distance values of alternatives (CC_i). Since one representative indicator of a company has six values from 2008 to 2013, the values of indicators are set into triangular fuzzy numbers and setting formula is presented as follows.

Let $b_{ij}(e)$ indicate the value of indicator *j* for company *i* on the period *e*, where *i* = 1, 2, …,13; *j* = 1,2,…,15; *e* = 2008, 2009,…,2013.

To reach the values of the six periods, the representative indicator of company *i* on indicator *j* presented with the triangular fuzzy number ($g_{ij}^l, g_{ij}^m, g_{ij}^r$) is defined as:

$$g_{ij}^l = \min\{b_{ij} \mid e = 2008, 2009, \ldots, 2013\}, \quad (23)$$

$$g_{ij}^m = \frac{1}{6}\sum_{e=2008}^{2013} b_{ij}(e) \quad (24)$$

and,

$$g_{ij}^r = \max\{b_{ij}(e) \mid e = 2008, 2009, \ldots, 2013\} \quad (25)$$

Utilizing the method of triangular fuzzy numbers, the fuzzy numbers of financial ratios are shown in Table 5.

Table 5. Triangular Fuzzy Numbers of Financial Ratios

	Current Ratio	Quick Ratio	Cash Ratio	Acc. Rec. Turnover	Equity Turnover
AKENR	(0.34,1.01,2.14)	(0.31,0.79,1.87)	(0.09,0.43,0.91)	(4.02,6.46,9.54)	(-40.75,-4.78,18.66)
AKSEN	(0.83,1.13,1.48)	(0.29,0.84,1.26)	(0.02,0.07,0.12)	(1.90,6.33,12.55)	(1.11,1.57,1.87)
AKSUE	(0.20,23.68,70.59)	(0.00,21.56,62.29)	(0.00,19.41,59.30)	(3.71,5654.58,33871)	(1.05,9.58,16.78)
ANELE	(1.11,1.49,1.78)	(0.29,0.84,1.26)	(0.02,0.07,0.12)	(1.28,3.48,5.62)	(1.11,1.57,1.87)
AVTUR	(0.45,27.46,145.6)	(0.16,16.25,85.89)	(0.00,15.61,85.81)	(1.81,334.0,917.0)	(0.02,72.94,160.79)
AYEN	(0.36,0.98,1.66)	(0.29,0.77,1.33)	(0.01,0.23,0.47)	(7.13,8.33,10.06)	(0.44,0.72,1.68)
AYGAZ	(0.97,1.51,1.90)	(0.82,1.02,1.34)	(0.26,0.47,0.73)	(11.25,15.90,18.40)	(-5.76,8.37,22.43)
EMKEL	(0.52,0.77,0.95)	(0.17,0.39,0.59)	(0.00,0.04,0.10)	(2.43,8.78,23.24)	(1.01,2.94,8.60)
GEREL	(1.25,1.88,2.79)	(0.60,1.07,2.04)	(0.08,0.34,0.57)	(3.72,5.87,8.36)	(1.85,2.35,2.86)
IPEKE	(2.00,4.68,8.47)	(1.23,3.91,7.40)	(0.72,3.55,7.03)	(18.23,28.57,47.55)	(1.39,1.72,1.99)
PETKM	(1.39,1.55,1.76)	(0.88,0.93,1.03)	(0.11,0.23,0.31)	(5.54,7.27,10.32)	(1.40,2.04,2.61)
TRCAS	(2.13,7.57,12.32)	(1.96,7.29,11.89)	(1.24,5.90,11.20)	(4.04,6.65,9.13)	(0.020,0.07,0.11)
ZOREN	(0.35,0.50,0.64)	(0.29,0.33,0.39)	(0.01,0.09,0.17)	(2.84,9.04,14.94)	(0.83,3.08,8.15)
	Fix. As. Turnover	**T. Assets Turnover**	**Debt Ratio**	**Debt To Equity Ratio**	**Return On Assets**
AKENR	(0.26,0.42,0.97)	(0.22,0.34,0.71)	(79.87,191.80,325.60)	(44.33,62.27,76.47)	(-9.57,0.00,10.36)
AKSEN	(0.47,0.74,1.02)	(0.31,0.48,0.63)	(163.1,232.7,303.2)	(61.99,69.17,75.19)	(-4.72,0.94,7.86)
AKSUE	(0.03,0.07,0.09)	(0.02,0.06,0.08)	(7.77,11.88,18.68)	(7.21,10.53,15.74)	(-5.88,1.83,10.03)
ANELE	(0.47,0.74,1.02)	(0.49,0.57,0.69)	(158.38,237.9,385.2)	(61.99,69.17,75.19)	(0.02,3.72,8.97)
AVTUR	(0.05,4.29,7.74)	(0.02,66.45,136.7)	(0.69,9.28,17.63)	(0.69,8.30,14.99)	(-3.96,-1.41,5.21)
AYEN	(0.17,0.27,0.38)	(0.16,0.22,0.32)	(93.45,203.45,421.13)	(47.18,61.12,79.25)	(-4.66,4.50,9.93)
AYGAZ	(2.15,2.49,2.83)	(1.45,1.72,2.01)	(24.19,42.09,70.80)	(19.47,28.44,40.21)	(1.70,8.91,13.94)
EMKEL	(0.75,1.32,2.88)	(0.49,0.74,1.14)	(-852.98,-9.22,245.53)	(51.22,69.18,113.28)	(-3.08,1.80,10.68)
GEREL	(1.53,2.96,5.55)	(0.79,1.10,1.59)	(53.40,125.51,193.50)	(34.81,52.46,65.93)	(-5.97,0.53,9.67)
IPEKE	(0.69,1.00,1.26)	(0.42,0.52,0.63)	(37.43,64.00,96.13)	(10.67,19.48,30.39)	(8.14,18.93,26.85)
PETKM	(1.63,2.43,3.20)	(0.97,1.31,1.55)	(25.19,55.42,90.08)	(20.12,34.56,47.39)	(-8.91,1.32,5.48)
TRCAS	(0.02,0.07,0.15)	(0.01,0.06,0.11)	(2.48,26.50,66.62)	(2.42,17.82,39.98)	(2.14,7.42,11.38)
ZOREN	(0.11,0.19,0.29)	(0.10,0.16,0.26)	(730.5,1645.7,3169.6)	(87.87,94.10,103.85)	(-13.86,-2.73,11.49)
	Return On Equity	**Net Profit Margin**	**Assets Growth**	**Shareh. Equity Growth**	**Sales Growth**
AKENR	(-40.75,-4.78,18.66)	(-38.1,-5.07,14.6)	(13.38,33.84,74.36)	(-31.65,19.35,79.82)	(-23.61,12.19,43.22)
AKSEN	(-17.99,2.49,20.7)	(-9.63,2.04,12.54)	(-1.95,30.15,97.60)	(-15.05,37.41,91.31)	(-2.97,48.01,107.89)
AKSUE	(-6.34,2.08,11.32)	(-74.4,32.5,134.4)	(-7.35,7.00,26.26)	(-5.41,5.23,23.29)	(-45.1,28.08,241.9)
ANELE	(-16.21,16.90,77.7)	(-9.63,2.04,12.54)	(-7.26,42.79,117.39)	(-15.05,37.41,91.31)	(-2.97,48.01,107.8)
AVTUR	(-4.16,-1.41,6.13)	(-147.7,-27.6,0.04)	(-17.68,398.7,2393.8)	(-3.8,372.03,2234.8)	(-96.87,-31.27,46.56)
AYEN	(-24.77,8.18,20.3)	(-14.76,22.4,43.4)	(-5.78,20.81,84.46)	(-15.50,0.73,9.42)	(3.14,27.74,90.20)
AYGAZ	(2.99,12.27,19.05)	(1.17,5.12,8.62)	(-3.26,5.72,9.00)	(2.21,2.45,2.68)	(2.39,11.34,23.00)
EMKEL	(-6.30,9.25,36.91)	(-6.25,1.15,10.19)	(15.65,44.41,89.69)	(-64.4,94.7,484.81)	(-31.22,25.4,62.09)
GEREL	(-16.96,-1.80,14.83)	(-5.92,-0.60,6.08)	(-3.09,39.42,134.26)	(-9.35,18.59,53.98)	(-17.88,22.02,85.06)
IPEKE	(0.87,1.89,3.76)	(18.47,36.08,47.5)	(10.81,49.98,104.21)	(6.86,47.87,106.10)	(-7.90,35.82,67.66)
PETKM	(-11.15,2.44,8.13)	(-6.52,1.28,5.54)	(-12.72,9.55,24.43)	(-11.44,2.09,8.85)	(-11.33,12.95,41.41)
TRCAS	(3.57,9.01,15.56)	(51.9,249,891.3)	(-0.74,15.78,53.26)	(-1.06,5.71,14.91)	(-79.0,288.3,1593.2)
ZOREN	(-351.3,-104.9,99.3)	(-106.2,-14.1,109)	(-6.89,39.05,128.82)	(-186.78,97.2,528.3)	(-20.72,7.51,41.99)

After applying the steps, as a result of Fuzzy TOPSIS method, we rank the performance scores based on the financial ratios of 13 energy firms traded in Borsa Istanbul. As can be seen in Table 6, AVTUR, TRCAS and AKSUE which have the highest, AKENR and ZOREN have the lowest performance scores for the period 2008-2013.

Table 6. Performance Scores of the Energy Firms

Rank	Firm	D_i^*	D_i-	CC_i
1	AVTUR	0.987135044	0.904008183	0.478022061
2	TRCAS	0.943099095	0.791095604	0.456174618
3	AKSUE	0.982482711	0.807398341	0.451090501
4	IPEKE	0.930515641	0.730387574	0.439753242
5	AYGAZ	0.958963687	0.686787676	0.417309498
6	ANELE	0.9968843	0.658097498	0.397646366
7	EMKEL	1.009747287	0.648650772	0.391130928
8	GEREL	1.011522564	0.642333239	0.388385274
9	PETKM	1.009197933	0.640250196	0.388160249
10	AYEN	1.017278487	0.63380406	0.383871819
11	AKSEN	1.025402439	0.623030297	0.377953121
12	AKENR	1.045277686	0.615486853	0.370604525
13	ZOREN	1.277522836	0.516842079	0.288036216

4. Conclusion

Energy has a critical impact on economic development level of countries due to being a driven force for the other sectors. Turkey's energy consumption has increased over the last years in parallel with industrialization and urbanization. Hence, energy sector has effect on other sectors of the economy, especially in the real economy. In this regard, financial performances of the firms must be followed-up due to the fact that any failure can affect all the economy.

The performance evaluation of the energy firms is an important issue especially in a competitive business environment for investors, creditors and also for the firms that are in the same sector since it settles firm's position in the sector. In addition, comparing a firm with others can identify the competitive strength and weakness of firm. In this respect, the results of the study provide useful information to the firms for reviewing their goals and strategies.

In the study, financial performances of Turkish energy firms are evaluated cover the period 2008-2013. Fuzzy AHP and Fuzzy TOPSIS methods are applied to the Turkish energy firms in order to evaluate the financial performances on the basis of 5 main criteria and 15 sub-criteria.

Firstly, the criteria used to measure the financial performance of the firms have been identified. Then, Fuzzy AHP method is utilized for the determination of the weights of the main and sub-criteria. The criteria of liquidity and profitability are the most significant with weight of 0.2963, followed by the criteria of growth ratio (0.1467), financial leverage ratio (0.1314) and the activity ratio (0.1294) respectively. Then Fuzzy TOPSIS method is used for the ranking of thirteen firms in terms of financial performances. Results show that AVTUR, TRCAS and AKSUE have the best performance among the energy firms after the global financial crisis.

The results are important for the firms to realize the financial position in the energy sector. Moreover, by means of the results, firm managers could focus on the most effective criteria and imitate the proper firm. Although the study provides important insights of financial performances of the energy firms, it is possible to change the rankings of the firms if the weights of the criteria are changed by decision makers. A further research may consider the results obtained in this paper with other fuzzy multi-criteria decision making methods or the utilized method can be applied to the firms which are operate in other sectors.

End Notes

[1] *where S_t is the net sales of the current period, and S_{t-1} is the net sales of the previous period.*

[2] *where A_t is the assets of the current period, and A_{t-1} is the assets of the previous period.*

[3] *where E_t is the shareholders' equity of the current period and Et_{-1} is shareholders' equity of the previous period.*

[4] *Fuzzy pairwise comparisons for the sub-criteria are presented in the appendix 2.*

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Appendix

1. Fuzzy Pairwise Comparisons for the Sub-Criteria

Liquidity Ratios			
	Current Ratio	Quick Ratio	Cash Ratio
Current Ratio	(1,1,1)	(3,5,7)	(1,1,3)
Quick Ratio	(0.143,0.2,0.333)	(1,1,1)	(0.2,0.333,1)
Cash Ratio	(0.333,1,1)	(1,3,5)	(1,1,1)

Activity Ratios				
	Accounts Receivable Turnover	Fixed Assets Turnover	Equity Turnover	Total Assets Turnover
Accounts Receivable Turnover	(1,1,1)	(1,3,5)	(3,5,7)	(1,3,5)
Fixed Assets Turnover	(0.2,0.333,1)	(1,1,1)	(3,5,7)	(1,3,5)
Equity Turnover	(0.143,0.2,0.333)	(0.143,0.2,0.333)	(1,1,1)	(1,1,3)
Total Assets Turnover	(0.2,0.333,1)	(0.2,0.333,1)	(0.333,1,1)	(1,1,1)

Leverage Ratios		
	Debt Ratio	Debt to Equity Ratio
Debt Ratio	(1,1,1)	(1,3,5)
Debt to Equity Ratio	(0.2,0.333,1)	(1,1,1)

Profitability Ratios			
	Return on Assets	Return on Equity	Net Profit Margin
Return on Assets	(1,1,1)	(1,3,5)	(1,3,5)
Return on Equity	(0.2,0.333,1)	(1,1,1)	(1,1,3)
Net Profit Margin	(0.2,0.333,1)	(0.333,1,1)	(1,1,1)

Growth Ratios			
	Sales Growth	Assets Growth	Shareholders' Equity Growth
Sales Growth	(1,1,1)	(1,3,5)	(3,5,7)
Assets Growth	(0.2,0.333,1)	(1,1,1)	(1,3,5)
Shareholders' Equity Growth	(0.143,0.2,0.333)	(0.2,0.333,1)	(1,1,1)

2. Questionnaire Forms

Main Criteria	Absolute	Very Strong	Fairly Strong	Weak	**Equal**	Weak	Fairly Strong	Very Strong	Absolute	
Growth Ratios										Activity Ratios
Growth Ratios										Financial Leverage Ratios
Growth Ratios										Profitability Ratios
Growth Ratios										Liquidity Ratios
Activity Ratios										Financial Leverage Ratios
Activity Ratios										Profitability Ratios
Activity Ratios										Liquidity Ratios
Financial Leverage Ratios										Profitability Ratios
Financial Leverage Ratios										Liquidity Ratios
Profitability Ratios										Liquidity Ratios

Liquidity Ratios	Absolute	Very Strong	Fairly Strong	Weak	**Equal**	Weak	Fairly Strong	Very Strong	Absolute	
Current Ratio										Quick Ratio
Current Ratio										Cash Ratio
Quick Ratio										Cash Ratio

Activity Ratios	Absolute	Very Strong	Fairly Strong	Weak	**Equal**	Weak	Fairly Strong	Very Strong	Absolute	
Accounts Receivable Turnover										Equity Turnover
Accounts Receivable Turnover										Fixed Assets Turnover
Accounts Receivable Turnover										Total Assets Turnover
Equity Turnover										Fixed Assets Turnover
Equity Turnover										Total Assets Turnover
Fixed Assets Turnover										Total Assets Turnover

Financial Leverage Ratios	Absolute	Very Strong	Fairly Strong	Weak	**Equal**	Weak	Fairly Strong	Very Strong	Absolute	
Debt Ratio										Debt to Equity Ratio

Profitability Ratios	Absolute	Very Strong	Fairly Strong	Weak	**Equal**	Weak	Fairly Strong	Very Strong	Absolute	
Return on Equity										Return on Assets
Return on Equity										Net Profit Margin
Return on Assets										Net Profit Margin

Growth Ratios	Absolute	Very Strong	Fairly Strong	Weak	**Equal**	Weak	Fairly Strong	Very Strong	Absolute	
Assets Growth										Shareholders' Equity Growth
Assets Growth										Sales Growth
Shareholders' Equity Growth										Sales Growth

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