SCIENTIFIC OASIS

Journal of Soft Computing and Decision Analytics

Journal homepage: www.jscda-journal.org
ISSN: 3009-3481

An Integrated Fuzzy MCDM and Trend Analysis Approach for Financial Performance Evaluation of Energy Companies in Borsa Istanbul Sustainability Index

Hakan Ayhan Dagistanli[1,*]

[1] Department of Industrial and System Engineering, Turkish Military Academy, National Defense University, Ankara, Turkiye

ARTICLE INFO

Article history:
Received 11 August 2023
Received in revised form 21 August 2023
Accepted 23 August 2023
Available online 25 August 2023

Keywords: Hesitant Fuzzy Sets; TOPSIS; MCDM; Financial Performance; Trend Analysis.

ABSTRACT

Financial performance evaluation is a great importance for companies. The aim of this study is to analyze the financial performances of energy companies traded in the Borsa Istanbul Sustainability Index in Turkey comparatively using trend analysis and multi-criteria decision making (MCDM). For this purpose, the changing values of accounting-based performance indicators over the years have been compiled from financial reports. The data were first evaluated by it was analyzed by Hesitant Fuzzy Technique for Order Preference by Similarity to Ideal Solution (HFTOPSIS). Then, it was analyzed by trend analysis for each variable separately. Comparative results show that MCDM rankings based on fuzzy set theory are different from analyzes performed alone. In addition, there is no study in the literature examining the financial performance of energy companies in Turkey based on the sustainability index.

1. Introduction

Energy is one of the important elements that contribute to the social and economic development of a country. Also, energy is one of the important elements that contribute to the social and economic development of a country. Turkey is one of the countries with the fastest growth in energy demand in the last 10 years among OECD countries. Oil and natural gas is outsourced due to the insufficient energy resources in Turkey. This means that Turkey's import dependency is high for these energies. The requirement for investment in the energy sector in Turkey until 2023 is expected to exceed 120-130 billion USD [1]. Electricity is an increasingly preferred energy source in light industry sectors, services and economies built on digital technology. In addition, the electricity demand in the world has increased twice as much as the energy need as a result of the increase in the digitalization trend [2]. The energy need required by the high growth potential and the performances of the companies operating in this sector are becoming important day by day when these situations are carefully examined.

* *Corresponding author.*
E-mail address: rdagistanli@kho.msu.edu.tr

https://doi.org/10.31181/jscda1120233

Performance is a criterion that can be measured and evaluated in terms of companieses. Companies that measure performance can determine how much of their goals they have achieved. Performance measurement in companies can be done in different ways. The most important point for companies is to measure and evaluate financial performance correctly. Moreover, the most important basis for the accurate measurement of financial performance is the transparency and reliability of the data that form the basis of financial performance. Companies can survive in today's conditions where competition is very intense thanks to accurate financial performance measurements. Therefore, all companies need financial performance measurement regardless of the sector. One of the critical points in the measurement is the criteria.

Financial performance criteria can be examined in 3 groups as market-based, accounting-based and perceptual measures in the study [3]. Perceptual measures, which are the first of these indicators, are determined subjectively by the survey evaluations of the company. Financial performance indicators in the literature were examined in 105 studies between 2002 and 2011. First of all, accounting-based indicators are frequently used in studies because they are objective and auditable. Studies with partially objective market-based indicators are less common than accounting-based studies. Finally, the rate of perceptual studies for direct subjective evaluations is very low [4]. In addition to the objectivity of accounting-based measures, the reason for using market-based measures is that they include the future expectations of stakeholders for company stocks [5]. In this study, ROA, ROE, ROS, and Size and FKal, which are accounting-based indicators with consensus in the literature about profitability objectivity, are taken as financial performance criteria.

The next step is the method used to measure the performance after the selection of the financial performance criteria. There is no single criterion that represents performance. Performance measurement with multiple criteria is a rational solution since the number and importance of the criteria vary. In this case, Multi-Criteria Decision Making (MCDM) methods for performance measurement are suitable alternatives for decision makers (DMs) [6]. There is no clear and satisfactory answer about which MCDM method is better or more appropriate to choose. For this reason, the method used in the studies is generally preferred with the guidance of the literature. On the other hand, methods in which financial statements are analyzed separately for each criterion are also used. In this context, the trend analysis method is among the most widely used analysis types [7]. The success of the past activities of the enterprise can be seen, as well as the future situation can be predicted with financial statements analysis. However, the accuracy and reliability of the information in the financial statements analysis is important to assist company managers in making the right decisions. Therefore, objective indicators would be appropriate to use.

The relationship between sustainability reporting and financial performance has been clearly demonstrated by many studies in the literature. Companies publish detailed information for all their activities on sustainability in their sustainability reports. Awareness about sustainability has increased in Turkey over the years with the increase in activities on a global basis. Thus, the Sustainability Index (XUSRD) was created at Borsa Istanbul. In this study, the sustainability reports of 4 companies operating in the energy sector in XUSRD between the years 2014-2021 were examined. In addition, data about the determined criteria were collected.

The purpose of this study is to measure the financial performance of energy companies traded in XUSRD. This study contributes to the literature in several different ways although there are many different studies in the literature. Major contributions of this study can be highlighted as follows: (1) FP indicators are not market-based and are free from manipulation. (2) In the literature, comparative analyzes were applied using Fuzzy MCDM and trend analysis methods instead of

MCDM analyzes based on fuzzy or clear, single or hybrid methods. (3) Financial performance data of companies that publish sustainability reports were collected. In this way, the literature on the relationship between sustainability reporting and financial performance has been enriched.

The rest of the paper is organized as follows. In the Section 2 of the study, extensive literature research was shared. In the Section 3, Fuzzy TOPSIS and Trend Analysis are presented. Section 4 includes the analysis results of the applied methods. Finally, results and comments are given in the Section 5.

2. Related Literature

In the literature, financial performance analysis has been made with MCDM in many different sectors and country stock markets. Decision making is an activity based on subjective or objective judgments. In objective judgments, mathematical models and algorithms are used while decision makers take into account their own experiences and thoughts in subjective judgments. Similarly, methods with strong mathematical background are chosen when evaluating alternatives. One of these methods is Technique For Order Preference By A Similarity To Ideal Solution (TOPSIS). Table 1 shows a summary of the literature review integrated with TOPSIS and other methods.

Table 1
Literature Summary for Financial Performance Analysis with TOPSIS Method

Year	References	Sector	Methods	Year	References	Sector	Methods
2012	[8]	Manufacturing	FAHP-TOPSIS, VIKOR	2021	[17]	Banking	TOPSIS
2014	[9]	Shipping	FTOPSIS	2021	[18]	Manufacturing	PROMETHEE-TOPSIS-WSA
2015	[10]	Greenex	FDEMATEL-TOPSIS	2021	[19]	Banking	AHP-FTOPSIS
2015	[11]	Real Estate Investment	Entropy-Based TOPSIS	2021	[20]	Banking	TOPSIS-FTOPSIS
2016	[12]	Petrochemical	FAHP-FTOPSIS	2022	[21]	Banking	CRITIC-DEMATEL-TOPSIS
2016	[13]	Energy	FAHP-FTOPSIS	2022	[22]	Stock Market	Entropy-DEMATEL-TOPSIS
2018	[14]	Automotive	TOPSIS	2023	[23]	Stock Market	Entropy-FTOPSIS
2019	[15]	Tourism	MAUT-TOPSIS-PROMETHEE	2023	[24]	Energy	AHP-TOPSIS
2020	[16]	Food Service	TOPSIS	2023	[25]	Energy	DEA-IRP-TOPSIS

In addition, studies that include trend analysis for financial performance evaluation have been carried out for a long time [26,27]. Today, trend analysis is still used as stand-alone and hybrid [28,29].

3. Methodology

3.1 Hesitant Fuzzy Sets

There have been many studies on various extensions of the concept since the first introduction of fuzzy sets by Zadeh in 1965 [30]. One of these extensions is the concept of Hesitant Fuzzy Sets (HFS) [31] introduced by Torra in 2010. The concept of membership functions, which show the degree of belonging to the set, is of great importance among all fuzzy extensions. a grades of non-membership is not defined as in intuitionistic fuzzy numbers or possible values depending on a probability distribution are not found as in Type-2 fuzzy numbers while defining the degrees of belonging to a cluster in hesitant fuzzy numbers. But there are a number of degrees of belonging. HFS is defined as a function that generates a set of membership grades for each element in the domain.

X is a reference set. HFS defined on X is expressed as a function h and this function converts set X to subset [0,1]. Each element of HFS is a subset of the h(x) finite and non-empty range [0,1]. The concepts of empty set and full set of HFS are given by Eq. (1) and Eq. (2) [31].

Empty Set: $h(x)=\{0\}\ \forall x \in X$ (1)

Full Set: $h(x)=\{1\}\ \forall x \in X$ (2)

The representation of HFS, A, is given by the following mathematical symbols.

$A=\{x, h_A(x)\ |x\in X\}$

Mathematically, $h_A(x)$ is include x∈X represents the possible membership degrees of set *A* and h= $h_A(x)$ is called hesitant fuzzy element [32]. H(x) is the set of all hesitant fuzzy elements on X. $h_A(x)$, where A ∈ H(x); for x∈A lower and upper limits are given with Eq.3 and Eq.4.

$$h_A^-(x) = minh_A(x) \tag{3}$$

$$h_A^+(x) = minh_A(x) \tag{4}$$

The identifier of HFS, A,B ∈ H(x), and the union and intersection operators of two HFS are defined in terms of hesitant fuzzy elements and given with Eq.5-7.

$$h_A^c(x) = U_{\gamma\in \mathrm{h_A(x)}}\{1-\gamma\} \tag{5}$$

$$h_{A(x)} U h_{B(x)} = U_{\gamma 1\in \mathrm{h_A(x)},\gamma 2\in \mathrm{h_B(x)}} \max\{\gamma_1,\gamma_2\} \tag{6}$$

$$h_{A(x)} \cap h_{B(x)} = U_{\gamma 1\in \mathrm{h_A(x)},\gamma 2\in \mathrm{h_B(x)}} \min\{\gamma_1,\gamma_2\} \tag{7}$$

Hesitant fuzzy elements are indicated by $h_{A(x)} = \{\gamma_1,\gamma_2 \dots, \gamma_{l,}\}$ for the reference set X. $\gamma_t(t = 1,2,\dots l)$ are the membership degrees of a particular set x∈X. l contains $h_{A(x)}$ is that the number of membership degrees.

Sum and scalar multiplication operators of hesitant fuzzy elements defined on HFS, A, B ∈ H(x), are given with Eq.8 and Eq.9.

$$h_{A(x)} \oplus h_{B(x)} = U_{\gamma 1\in \mathrm{h_A(x)},\gamma 2\in \mathrm{h_B(x)}}\{\gamma_1+\gamma_2-\gamma_1\gamma_2\} \tag{8}$$

$$\beta h_{A(x)} = U_{\gamma 1\in \mathrm{h_A(x)}}\{1-(1-\gamma)^{\beta}\}, \beta > 0 \tag{9}$$

3.2 Hesitant Fuzzy TOPSIS

The TOPSIS method, first developed by Hwang and Yoon [33], is a simple and useful decision-making method for tackling MCDM problems with precise data. The basic idea of the TOPSIS method is that the optimal alternative has the shortest distance from the positive ideal solution (PIS) and the farthest distance from the negative ideal solution (NIS).

Decision makers, who are undecided in the evaluation of alternatives on the basis of criteria, may want to rank their alternatives by using all of their decisions. In this case, hesitant fuzzy TOPSIS may be a suitable method. The hesitant fuzzy TOPSIS algorithm is given below.

Step 1. Identify alternatives, criteria and criterion weights.

m alternatives as {A_1, A_2, …, A_m} and n criteria as { C_1, C_2, …, C_n } are determined. The weight vector for the criteria is demonsrated by Kriterlere w =(w_1, w_2, …, w_n). w_j is the weight of the C_j criterion. Additionally, $\sum_j^n w_j$ and 0< wj <1, j= 1,2, … , n .

Step 2. The hesitant fuzzy decision matrix is expressed as:

$$R= (h_{ij})mxn = \begin{bmatrix} h_{11} & h_{12} & \cdots & h_{1n} \\ h_{21} & h_{22} & \cdots & h_{2n} \\ \vdots & \vdots & \ddots & \vdots \\ h_{m1} & h_{m2} & \cdots & h_{mn} \end{bmatrix} \quad (10)$$

Step 3. Create the hesitant fuzzy normalized decision matrix.

Each hesitant fuzzy element in the R matrix is set to *l*, which is the number of membership degrees h_{ij} contains to normalize the hesitant fuzzy decision matrix given in step 2. The normalization process is carried out by adding the membership degree with the smallest value in the unstable fuzzy element to the set [34-36].

Step 4. The hesitant fuzzy positive ideal solution PIS A^+ and the hesitant fuzzy negative ideal solution NIS A^- are determined.

$$A^+ = (h_1^+, h_2^+, \dots, h_n^+) = (\begin{pmatrix} (H\{max_i\ y_{ij}^1, max_i\ y_{ij}^2, \dots, max_i\ y_{ij}^l\} \setminus C_j \in J_{\text{I}}) \\ veya(H\{min_i\ y_{ij}^1, min_i\ y_{ij}^2, \dots, min_i\ y_{ij}^l\} \setminus C_j \in J_{\text{II}}) \end{pmatrix} \quad (11)$$

J_{I} denotes the set of benefit criteria and J_{II} the set of penalty criteria. The distance between $A_i\ (i = 1,2, \dots, n)$ and the hesitant fuzzy PIS A^+ is calculated with the unstable fuzzy Euclidean distance $d^h(A_i, A^+)$ given by Eq.12.

$$d^h(A_i, A^+) = \sum_{j=1}^n w_j \sqrt{\frac{1}{l} \sum_{\lambda=1}^l (Y_{ij}^\lambda - (Y_j^\lambda)^+)^2} \quad (12)$$

The unstable fuzzy negative ideal solution is calculated by PIS A^- in Eq.13.

$$A^- = (h_1^-, h_2^-, \dots, h_n^-) = (\begin{pmatrix} (H\{min_i\ y_{ij}^1, min_i\ y_{ij}^2, \dots, min_i\ y_{ij}^l\} \setminus C_j \in J_{\text{I}}) \\ veya(H\{max_i\ y_{ij}^1, max_i\ y_{ij}^2, \dots, max_i\ y_{ij}^l\} \setminus C_j \in J_{\text{II}}) \end{pmatrix} \quad (13)$$

The distance between $A_i\ (i = 1,2, \dots, n)$ and the hesitant fuzzy NIS A^- is calculated by the unstable fuzzy Euclidean distance $d^h(A_i, A^-)$ given by Eq.14.

$$d^h(A_i, A^-) = \sum_{j=1}^n w_j \sqrt{\frac{1}{l} \sum_{\lambda=1}^l (Y_{ij}^\lambda - (Y_j^\lambda)^-)^2} \quad (14)$$

Step 5. The proximity index$F^h(A_i)$ of $A_i\ (i = 1,2, \dots, n)$ is calculated. The proximity index $F^h(A_i)$ is calculated by Eq.15.

$$F^h(A_i) = \frac{d^h(A^i, A^-)}{d_{max}^h(A^i, A^-)} - \frac{d^h(A^i, A^+)}{d_{min}^h(A^i, A^+)} \quad (15)$$

$d_{max}^h(A^i, A^-) = max_{1 \le i \le m} d^h(A^*, A^-)$ and $d_{min}^h(A^i, A^+) = min_{1 \le i \le m} d^h(A^*, A^+)$. The proximity index provides the closest A_i alternative to the hesitant fuzzy PIS A^+ and the farthest A_i alternative to the hesitant fuzzy NIS A^-.

Step 6. Alternatives are listed.

It is clear that $F^h(A_i) \le 0$ and the alternative with the largest $F^h(A_i)$ is the best alternative. The alternatives are ranked from the largest to the smallest according to the proximity index.

3.3 Trend Analysis

Trend analysis is a suitable method in terms of showing the changes in the financial condition of the companies and the results of its activities in longer time periods compared to other methods. However, there should be significant relationships between the balance sheet and income statement items to be analyzed and it should cover a period of approximately 5-6 years in order for this change to be determined correctly. In this method, the selection of the year that will form the basis of the analysis is as important as the years to be included in the analysis. Therefore, it should be noted that the base year is a normal year. Otherwise, the wrong selection of the base year may lead to incorrect and misinterpretation of the results that will emerge in the following years [37].

Trend analysis allows the analyst to make a dynamic analysis by revealing the increase or decrease in the financial statements of the companies as of certain periods and their effects on the financial statements [38]. However, trend analysis also has some limitations and these should be considered when interpreting the analysis results. For example, if a very bad year is chosen in the selection of the base year, the improvements in the following years can be evaluated much more positively, while if a very good year is chosen, the improvements in the following years can be evaluated more negatively. Increases in items with low materiality level in terms of financial statements can be considered exaggerated. For this reason, in the evaluation of increases or decreases, not only the proportional increase but also the amounts of these increases and decreases should be taken into account. In addition, the analysis may become meaningless if the significant accounting policies, valuation methods, and the effects of price and exchange rate movements during the review period are not taken into account [38]. In trend analysis, two methods are used to compare financial statement items. These are the change from the base year and the change from the previous year. In this study, the trend of change in the energy sector was analyzed based on the base year.

4. Application

4.1. Application of Hesitant Fuzzy TOPSIS

In this section, the criteria values determined C_1: ROA, C_2: ROE, C_3: ROS, C_4: BUY, C_5: LEV will be used to rank the 4 energy alternatives in XUSRD, following the methodology described above. The steps of applying the method are described below. Explanations of the variables are given in Table 2.

Table 2
Definition of Criteria

Symbol	Description/Calculation
ROA	Net Profit/Total Assets
ROE	Net Profit/Equity
ROS	Net Profit/Total Sales
SIZE	Natural Logarithm of Total Assets
LEV	Financial Leverage = Total Liabilities/Equity

Step 1. The alternative set $\{A_1, A_2, A_3, A_4\}$ and the criterion set $\{C_1,\ C_2, \dots, C_5\}$ are determined. The weight vector of the criteria is taken as an example according to the opinions of the decision makers.

Step 2. Determine the hesitant fuzzy decision matrix.

Table 3 gives information about the hesitant fuzzy decision matrix. While creating this information, the information in the sustainability reports of the financial performance criteria was used. This information is not presented with a single data, but is presented as values that can be within certain intervals and between two or three limit values, obtained as a result of expert evaluation and assigned a value in the range of [0,1]. This situation is evaluated as the “degree of indecision” of the data and can be transformed into Table 1 by the normalization or transformation process as seen in Table 1. After this point, the hesitant TOPSIS method can be applied step by step by using the unstable fuzzy decision matrix in Table 3.

Table 3
Hesitant Fuzzy Decision Matrix

	C_1	C_2	C_3	C_4	C_5
AKENR	{0.418,0.349,0.233}	{0.010,0.020,0.900}	{0.417,0.320,0.262}	{0.330,0.330,0.340}	{0.010,0.020,0.900}
AKSEN	{0.219,0.279,0.502}	{0.239,0.281,0.480}	{0.230,0.254,0.516}	{0.329,0.330,0.341}	{0.379,0.326,0.294}
ENJSA	{0.217,0.377,0.406}	{0.230,0.370,0.400}	{0.208,0.381,0.411}	{0.328,0.331,0.340}	{0.411,0.297,0.292}
ZOREN	{0.010,0.030,0.080}	{0.001,0.003,0.005}	{0.397,0.632,0.765}	{0.330,0.332,0.339}	{0.433,0.355,0.202}

Step 3. Hesitant fuzzy normalized matrix is created.

The number of membership degrees in each h_{ij} $i = 1,2,\dots,4$ and $j = 1,2,\dots,5$ hesitant fuzzy elements are equalized as *l*=3 in the hesitant fuzzy decision matrix given in Table 3. The synchronization is done by adding the smallest membership degree.

Step 4. In Eq.11, PIS A^+ is that the hesitant fuzzy positive ideal solution as C_1, C_3, C_4, C_5, ϵJ_{I} and $C_2 \epsilon J_{\mathrm{II}}$ is calculated.

$$A^+ = (h_1^+, h_2^+, \dots, h_n^+)$$
$$= (\{0.418,0.377,0.502\}, \{0.239,0.370,0.900\}, \{0.417,0.632,0.765\}, \{0.330,0.332,0.341\}, \{0.010,0.020,0.202\})$$

PIS A^- is that the hesitant fuzzy negative ideal solution is calculated in Eq.12.

$$A^- = (h_1^-, h_2^-, \dots, h_n^-)$$
$$= (\{0.010,0.030,0.080\}, \{0.001,0.003,0.005\}, \{0.208,0.254,0.262\}, \{0.328,0.330,0.339\}, \{0.443,0.355,0.900\})$$

Step 5-6. The proximity index $F^h(A_i)$, $i = 1,2,3,4$ is calculated for each alternative. The best alternative is determined by arranging the proximity index from largest to smallest. The best alternative was found to be A_1. Table 4 includes euclidean distances and proximity index values for alternatives.

Table 4
Euclidean Distances and Proximity Index

Alternatives	d(A,A+)	d(A,A-)	F(Ai)
AKENR	0.037	0.050	-0.540
AKSEN	0.024	0.037	-0.264
ENJSA	0.026	0.035	-0.394
ZOREN	0.062	0.032	-1.931

The AKSEN alternative took the first place according to the results. Figure 1 gives the ranking results.

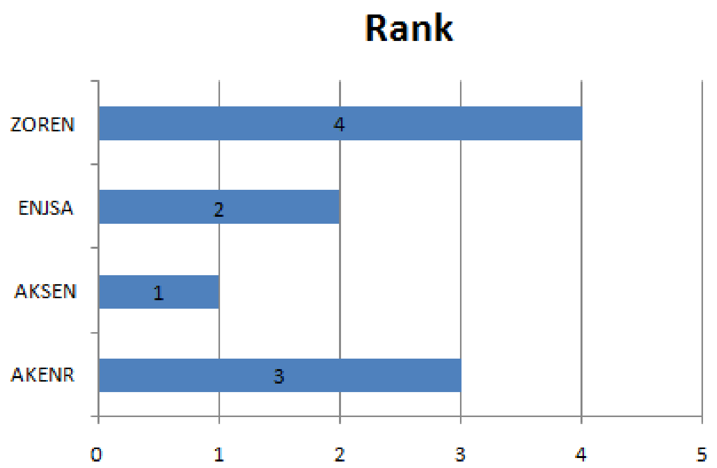

Fig. 1. Rankings of Energy Companies

4.2 Application of Trend Analyzes

In the study, energy companies included in the index in XUSRD since the year it was founded were examined. The data for 2022 are not included in the analysis since they have not been published yet. Trend analysis method was used to compare the performances of AKENR, AKSEN, ENJSA and ZOREN companies for the period 2014-2021. Also, Microsoft (MS) Excel computer program was used in the analysis of the data. In Table 5 gives the financial statement values of the companies included in the study, which are compared with the financial performance indicators.

Table 5
Financial Performance Values of the Companies Included in the Analysis

	Alternatives	2014	2015	2016	2017	2018	2019	2020	2021
ROA	AKENR	-0.099	-0.066	-0.109	-0.087	-0.273	-0.108	-0.161	-0.193
	AKSEN	0.011	-0.056	-0.087	0.069	0.004	0.039	0.049	0.089
	ENJSA	-0.022	0.024	0.025	0.053	0.033	0.044	0.044	0.073
	ZOREN	-0.045	-0.048	-0.001	0.005	0.002	-0.007	0.003	-0.005
ROE	AKENR	-0.632	-0.215	-0.499	-0.280	-3.379	-0.771	8.435	-1.603
	AKSEN	0.039	-0.287	-0.938	0.214	0.014	0.086	0.102	0.173
	ENJSA	-0.068	0.077	0.080	0.168	0.119	0.151	0.152	0.244
	ZOREN	-0.423	-0.355	-0.009	0.031	0.015	-0.085	0.032	-0.026
ROS	AKENR	-0.286	-0.195	-0.386	-0.272	-0.702	-0.406	-0.496	-0.646
	AKSEN	0.020	-0.098	-0.114	0.099	0.006	0.059	0.065	0.132
	ENJSA	-0.034	0.037	0.041	0.080	0.041	0.053	0.050	0.075
	ZOREN	-0.278	-0.465	-0.003	0.013	0.005	-0.017	0.009	-0.014
SIZE	AKENR	21.900	22.397	22.342	22.481	22.465	22.651	22.631	23.297
	AKSEN	21.964	22.125	22.147	22.374	22.586	22.863	22.975	23.751
	ENJSA	23.270	23.364	23.440	23.646	23.841	23.876	23.929	24.168
	ZOREN	22.325	22.449	22.646	23.146	23.566	23.650	23.787	24.291
LEV	AKENR	5.385	2.260	3.585	2.215	11.386	6.152	-53.363	7.308
	AKSEN	2.385	4.144	9.719	2.125	2.541	1.226	1.054	0.951
	ENJSA	2.159	2.212	2.188	2.161	2.587	2.423	2.450	2.351
	ZOREN	8.362	6.463	13.721	5.703	6.245	10.391	8.317	4.731

In the study, the trend analyzes for the performance indicators of the companies for the years 2014-2021 are given in Figure 2 and the comparative rankings are given in Table 6.

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Volume 1, Issue 1 (2023) 39-49

Fig. 2. Trend Analysis with Financial Performance Values

Although the rankings for ROA, ROS and LEV are the same, ROE and SIZE are different. HFTOPSIS results are different from all trend analysis rankings.

Table 6
Definition of Criteria

Alternatives	ROA	ROE	ROS	SIZE	LEV	HFTOPSIS
AKENR	4	4	4	4	4	3
AKSEN	1	2	1	3	1	1
ENJSA	2	1	2	2	2	2
ZOREN	3	3	3	1	3	4

5. Conclusions

The financial performance analysis of energy companies in XUSRD was calculated with the HFTOPSIS method in this study. In the method, starting from the unstable fuzzy decision matrix, the application steps are completed. In addition, the financial performance criteria were examined one by one with the trend analysis method and the differences were revealed with the Fuzzy MCDM.

The unstable fuzzy TOPSIS method applied in the study is particularly beneficial due to the use of the values of the objective financial performance criteria of the alternatives. On the other hand, in the TOPSIS method where integer values are used, a single value in the range should be taken, especially when using data related to the criterion working value presented in a certain range. This situation brings the uncertainty of the single value calculated in the financial performance values. In the HFTOPSIS application, the decision matrix is formed by taking into account the different values that can be obtained for all years. It can enable a more appropriate analysis to be made, especially for the criteria values that are given as intervals or that change over the years.

Instead of the TOPSIS method applied in the study, distance-based MCDM methods such as VIKOR, GRA, MOORA can also be used. The reasons for the differences in the rankings for different applications and which method is more useful can be analyzed by comparing the results obtained from these methods.

Acknowledgement

This research was not funded by any grant.

Conflicts of Interest

The author declare no conflicts of interest.

References

[1] Akbalık, M., & Kavcıoğlu, Ş. (2013). Energy Sector Outlook in Turkey. Dumlupınar Üniversitesi Sosyal Bilimler Dergisi, EYİ Özel Sayısı, 97-118.
[2] KPMG, Sektörel Bakış-Enerji. (2019). https://home.kpmg/tr/tr/home/gorusler/2019/07/sektorel-bakis2019.html
[3] Orlitzky, M., Schmidt, F. L., & ve Rynes, S. L. (2003). Corporate social and financial performance: A meta-analysis. Organization Studies, 24(3), 403-441. https://doi.org/10.1177/0170840603024003910
[4] Lu, W., Chau, K. W. Wang, H., & ve Pan, W. (2014). A decade's debate on the nexus between corporate social and corporate financial performance: a critical review of empirical studies 2002-2011. Journal of Cleaner Production, 79, 195-206. https://doi.org/10.1016/j.jclepro.2014.04.072
[5] Düzer, M., & ve Önce, S. (2017). Kurumsal sürdürülebilirlik raporlaması ve finansal performans: bist'te işlem gören şirketler için karşılaştırmalı bir analiz. Bilecik Şeyh Edebali Üniversitesi Sosyal Bilimler Dergisi, 2(2), 637-648. https://doi.org/10.33905/bseusbed.348073
[6] Danesh, D., Ryan, M. J., & Abbasi, A. (2017). A systematic comparison of multi-criteria decision making methods for the improvement of project portfolio management in complex organisations, International Journal of Management and Decision Making, 16(3), 280-320. https://doi.org/10.1504/IJMDM.2017.085638
[7] Jha, M. K., & Rangarajan, K. (2020). Analysis of corporate sustainability performance and corporate financial performance causal linkage in the Indian context. Asian Journal of Sustainability and Social Responsibility, 5(1), 1-30. https://doi.org/10.1186/s41180-020-00038-z
[8] Yalcin, N., Bayrakdaroglu, 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. https://doi.org/10.1016/j.eswa.2011.07.024
[9] Wang, Y. J. (2014). The evaluation of financial performance for Taiwan container shipping companies by fuzzy TOPSIS. Applied Soft Computing, 22, 28-35. https://doi.org/10.1016/j.asoc.2014.03.021
[10] Visalakshmi, S., Lakshmi, P., Shama, M. S., & Vijayakumar, K. (2015). An integrated fuzzy DEMATEL-TOPSIS approach for financial performance evaluation of GREENEX industries. International Journal of Operational Research, 23(3), 340-362. https://doi.org/10.1504/IJOR.2015.069626
[11] Islamoglu, M., Apan, M., & Oztel, A. (2015). An evaluation of the financial performance of REITs in Borsa Istanbul: A case study using the entropy-based TOPSIS method. International Journal of Financial Research, 6(2), 124-138. https://doi.org/10.5430/ijfr.v6n2p124
[12] Shaverdi, M., Ramezani, I., Tahmasebi, R., & Rostamy, A. A. A. (2016). Combining fuzzy AHP and fuzzy TOPSIS with financial ratios to design a novel performance evaluation model. International Journal of Fuzzy Systems, 18, 248-262. https://doi.org/10.1007/s40815-016-0142-8
[13] Eyüboglu, K., & Çelik, P. (2016). Financial performance evaluation of Turkish energy companies with fuzzy AHP and fuzzy TOPSIS methods. Business and economics research Journal, 7(3), 21. https://doi.org/10.20409/berj.2016321806
[14] Yadav, S. K., & Kapoor, R. (2018). Financial performance ranking of automotive companies in India using TOPSIS method. International Journal of Business Excellence, 16(2), 149-161. https://doi.org/10.1504/IJBEX.2018.094702

[15] Aytekin, A. (2019). Evaluation of the financial performance of tourism companies traded in BIST via a hybrid MCDM model. International Journal of Applied Research in Management and Economics, 2(4), 20-32. https://doi.org/10.33422/ijarme.v2i4.274
[16] Hoe, L. W., Siew, L. W., Fai, L. K., Xin, A. L. J., & Fun, L. P. (2020). An empirical evaluation on the performance of food service industry in Malaysia with TOPSIS model. In Journal of Physics: Conference Series, 1706(1), 012172. IOP Publishing. https://doi.org/10.1088/1742-6596/1706/1/012172
[17] Ova, A. (2021). Analyzing Financial Performance of Turkish Deposit Banks Using TOPSIS Method. Pamukkale Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 45, 1-13. https://doi.org/10.30794/pausbed.796587
[18] Baydaş, M., & Elma, O. E. (2021). An objectıve criteria proposal for the comparison of MCDM and weighting methods in financial performance measurement: An application in Borsa Istanbul. Decision Making: Applications in Management and Engineering, 4(2), 257-279. https://doi.org/10.31181/dmame210402257b
[19] Gupta, S., Mathew, M., Gupta, S., & Dawar, V. (2021). Benchmarking the private sector banks in India using MCDM approach. Journal of Public Affairs, 21(2), e2409. https://doi.org/10.1002/pa.2409
[20] Roy, P., & Patro, B. (2021). Financial performance analysis of NBFC-MFIs in India using TOPSIS and IV-TOPSIS. International Journal of Mathematical, Engineering and Management Sciences, 6(5), 1423. https://doi.org/10.33889/IJMEMS.2021.6.5.086
[21] Nguyen, P. H., Tsai, J. F., Hu, Y. C., & Ajay Kumar, G. V. (2022). A Hybrid method of MCDM for evaluating financial performance of vietnamese commercial banks under COVID-19 impacts. Shifting Economic, Financial and Banking Paradigm: New Systems to Encounter COVID-19, 23-45. https://doi.org/10.1007/978-3-030-79610-5_2
[22] Liew, K. F., Lam, W. S., & Lam, W. H. (2022). Financial Network Analysis on the Performance of Companies Using Integrated Entropy-DEMATEL-TOPSIS Model. Entropy, 24(8), 1056. https://doi.org/10.3390/e24081056
[23] Lam, W. H., Lam, W. S., Liew, K. F., & Lee, P. F. (2023). Decision Analysis on the Financial Performance of Companies Using Integrated Entropy-Fuzzy TOPSIS Model. Mathematics, 11(2), 397. https://doi.org/10.3390/math11020397
[24] Makki, A. A., & Alqahtani, A. Y. (2023). Capturing the effect of the COVID-19 pandemic outbreak on the financial performance disparities in the energy sector: A Hybrid MCDM-Based evaluation approach. Economies, 11(2), 61. https://doi.org/10.3390/economies11020061
[25] Patyal, V. S., Kumar, R., Lamba, K., & Maheshwari, S. (2023). Performance evaluation of Indian electricity distribution companies: An integrated DEA-IRP-TOPSIS approach. Energy Economics, 106796. https://doi.org/10.1016/j.eneco.2023.106796
[26] Acar, M. (2003). Tarımsal işletmelerde finansal performans analizi. Erciyes Üniversitesi İktisadi ve İdari Bilimler Fakültesi Dergisi, (20).
[27] Özgülbaş, N. (2006). Türkiye'de kamu hastanelerinin finansal durum değerlendirmede kullanılabilecekleri bir yöntem: trend analizi. Muhasebe ve Finansman Dergisi, (29), 129-139.
[28] Özari, Ç., & Erol, E. D. (2019). Trend Analizi ve Gri İlişkisel Analiz Yöntemleriyle Finansal Performans Analizi. R&S-Research Studies Anatolia Journal, 2(5), 230-246. https://doi.org/10.33723/rs.521748
[29] Koçyiğit, S. Ç., Biyik, E., & Ertaş, Ş. (2022). Özel bir sağlık işletmesinin finansal performansının trend analizi ile değerlendirilmesi. Abant Sosyal Bilimler Dergisi, 22(1), 165-180. https://doi.org/10.11616/asbi.1015793
[30] Zadeh, L. A. (1965). Fuzzy sets. Information and control, 8(3), 338-353. https://doi.org/10.1016/S0019-9958(65)90241-X
[31] Torra, V. (2010). Hesitant fuzzy sets. International journal of intelligent systems, 25(6), 529-539. https://doi.org/10.1002/int.20418
[32] Xia, M., & Xu, Z. (2011). Hesitant fuzzy information aggregation in decision making. International journal of approximate reasoning, 52(3), 395-407. https://doi.org/10.1016/j.ijar.2010.09.002
[33] Hwang, C. L., & Yoon, K. (1981). Methods for multiple attribute decision making. Multiple attribute decision making: methods and applications a state-of-the-art survey, 58-191. https://doi.org/10.1007/978-3-642-48318-9_3
[34] Xu, Z., & Xia, M. (2011). Distance and similarity measures for hesitant fuzzy sets. Information sciences, 181(11), 2128-2138. https://doi.org/10.1016/j.ins.2011.01.028
[35] Zhang, X., & Xu, Z. (2014). Extension of TOPSIS to multiple criteria decision making with Pythagorean fuzzy sets. International journal of intelligent systems, 29(12), 1061-1078. https://doi.org/10.1002/int.21676
[36] Zhang, X., & Xu, Z. (2017). Hesitant fuzzy methods for multiple criteria decision analysis. Switzerland: Springer International Publishing. https://doi.org/10.1007/978-3-319-42001-1
[37] Karagül, A. A., Çabuk, A., Erol, C., Bahar, B., Sevim, Ş., & Sayılır, Ö. (2013). Finansal Tablolar Analizi. Anadolu Üniversitesi Yayınları, Eskişehir.
[38] Akgüç, Ö. (2011). Mali Tablolar Analizi (14. b.). İstanbul: Avcıol Basım Yayın.