PERFORMANCE EVALUATION OF ENERGY COMPANIES WITH A NOVEL INTEGRATED MULTI-CRITERIA DECISION MAKING METHOD[1]

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ABSTRACT

Financial statements are an important tool for assessing and analyzing an organization's financial performance. Financial performance analysis allows for an accurate and appropriate appraisal of an organization's performance. The evaluation procedure must be thoroughly stated because financial performance indicators represent a company's competitiveness. This study provides a novel integrated multi-criteria decision-making method for analyzing an organization's financial performance. The applicability of the proposed method is assessed employing financial ratios that are integrated to generate a financial performance score for eight well-known Turkish energy companies. The criteria are weighted using the entropy method in the proposed method. The multi-attributive border approximation area comparison (MABAC) method is used to rank the companies. As the weights of the criteria have an impact on the ranking outcomes, a sensitivity analysis of the weights is performed. We also exhibit a comparison analysis of energy company rankings to validate the proposed approach's results using four MCDM methods: ELECTRE, MAUT, TOPSIS, and WASPAS. In addition, an alternative weighting method is also used to evaluate the results. The results show that the proposed method is an effective MCDM for coping with evaluation problems.

Keywords: *Performance evaluation, financial ratios, MCDM, MABAC*
JEL Codes: *M1, C02, C44*

Scope: *Business administration*
Type: *Research*

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[1] The necessary ethics committee permission was obtained for the study to be conducted.

ENERJİ ŞİRKETLERİNİN PERFORMANSININ YENİ BİR ENTEGRE ÇOK KRİTERLİ KARAR VERME YÖNTEMİYLE DEĞERLENDİRİLMESİ

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ÖZ | Mali tablolar, bir kuruluşun mali performansını değerlendirmek ve analiz etmek için önemli bir araçtır. Finansal performans analizi, bir organizasyonun performansının doğru ve uygun bir şekilde değerlendirilmesini sağlar. Finansal performans göstergeleri bir şirketin rekabet gücünü temsil ettiğinden, değerlendirme prosedürü kapsamlı bir şekilde belirtilmelidir. Bu çalışma, bir organizasyonun finansal performansını analiz etmek için yeni bir entegre çok kriterli karar verme yöntemi sunmaktadır. Önerilen yöntemin uygulanabilirliği, sekiz tanınmış Türk enerji şirketi için bir finansal performans puanı oluşturmak üzere entegre edilmiş finansal oranlar kullanılarak değerlendirilmiştir. Önerilen yöntemde kriterler entropi yöntemi kullanılarak ağırlıklandırılmıştır. Firmaların sıralanmasında çok nitelikli sınır yakınlaştırma alanı karşılaştırması (MABAC) yöntemi kullanılmaktadır. Kriterlerin ağırlıklarının sıralama sonuçları üzerinde etkisi olduğu için ağırlıkların bir duyarlılık analizi yapılmıştır. Ayrıca dört MCDM yöntemi: ELECTRE, MAUT, TOPSIS ve WASPAS kullanarak önerilen yaklaşımın sonuçlarını doğrulamak için enerji şirketi sıralamalarının bir karşılaştırma analizini de sunulmuştur. Ayrıca sonuçları değerlendirmek için alternatif bir ağırlıklandırma yöntemi de kullanılmaktadır. Sonuçlar, önerilen yöntemin değerlendirme problemleriyle başa çıkmak için etkili bir ÇKKV olduğunu göstermektedir.

Anahtar Kelimeler: *Performans değerlendirme, finansal oranlar, ÇKKV, MABAC*
JEL Kodları*: M1, C02, C44*

Alan: *İşletme*
Türü: *Araştırma*

1. INTRODUCTION

In today's global environment, competition has become inevitable. Companies' ability to survive in this competitive market is determined by how well they manage their decision-making processes and implement a well-defined performance evaluation strategy. Financial performance measurements are required for them to survive and gain a competitive advantage, as well as to ensure their long-term availability. Financial performance measurement can be used to determine a company's financial status, investment efficiency, and risk levels, based on these financial data. Financial ratios, which are generated utilizing data from income statements and balance sheets, are key instruments for evaluating and ranking a company's performance. The benefits of financial ratios are presented in several studies in the literature. They provide accurate and useful information and reveal the strong and weak features of companies in terms of financial ratios.

The energy sector is one of the fastest-growing in the world. This condition elevates the sector's relevance for Turkey in terms of foreign energy consumption. The fact that there is a link across industries is undeniable, but the energy sector is the basis of these sectors. Production lines and service providers' products and services are directly related to the amount of energy they consume. Because of its labor-intensive structure and traditional production process, the energy sector is an essential industrialization approach that has the ability to increase production volume, employment, and international trade benefit for many countries, particularly emerging ones. The increasing relevance of the energy sector has prompted energy companies to take action by regularly monitoring their performance. The companies examine their performance via financial ratios and decision-making methods. Researchers have recently become interested in decision-making methods. The performance ranking of parts is evaluated using multi-criteria decision making methods. These methods are designed to obtain the appropriate result based on the criteria and weights provided by various decision-making units.

Many publications compare organizational performance and highlight the effects of various factors on organizational performance. There are few articles that analyze the financial performance of the energy sector using multi-criteria decision-making methods. Yalçın et al. (2012) used fuzzy analytic hierarchy process (FAHP) for assessing the criteria weights and TOPSIS and VIKOR to evaluate the financial performance of Turkish manufacturing industries. Bulgurcu (2012) analyzed the financial performance of technology firms in Istanbul Stock Exchange by using TOPSIS. Shaverdi et al. (2014) used FAHP for the financial performance evaluation of the Iranian Petrochemical sector. Safaei Ghadikolaei et al. (2014) proposed a hybrid approach for the financial performance evaluation of automotive companies of Tehran stock Exchange. The criteria weights are determined by using FAHP and the ranking of the alternatives are performed by using fuzzy VIKOR, fuzzy COPRAS, fuzzy ARAS. Chang and Tasi (2016) used a hybrid financial performance evaluation based on AHP and VIKOR for wealth management banks. Metin et al. (2017) analyzed the financial performance of the energy sector in Turkey using TOPSIS and MOORA methods for the period of 2010-2015. Perçin and Aldalou (2018) evaluated the financial performance of Turkish airline companies using FAHP and fuzzy TOPSIS. Abdel-Basset et al. (2020) proposed an integrated plithogenic MCDM for evaluating the financial performance of manufacturing industries. Vibhakar et al. (2021) used entropy and simple additive weighting methods for the Indian construction companies. Çiftçi et al. (2021) suggested a hybrid approach included CoCoSo, CRITIC and weighted sum method to analyze the performance of energy companies based on cash flow ratios. According to the literature review, there is a gap in the literature for analyzing the financial performance of Turkish energy companies.

The purpose of this study is to evaluate the financial performance of Borsa Istanbul (BIST)-registered energy companies in Turkey. The following is a list of the study's contributions.

- Energy companies are considered in the study because of their strategic importance to national economies and their propensity to strengthen them. There are various studies in the literature about energy companies. Apart from the existing literature, this study presents the financial performance evaluation of BIST energy sector companies for the period of 2016-2020 in Turkey.
- To analyze the financial performance of energy sector companies, a hybrid method based on entropy and MABAC is proposed in the study. To the best of our knowledge, the proposed method has not been tailored to assess the financial performance of energy companies.
- The weights of the evaluation criteria are presumed to be equal in the literature generally. Different criterion weighting methods such as entropy, CRITIC methods are utilized in this study, and the results are compared. The financial ratios of eight BIST-registered companies are utilized as evaluation criteria in the study.
- Only a decision matrix is used in the proposed method for calculating the criterion weighting and ranking of alternatives. In this method, results can be obtained without relying on personal judgement and with fewer data.
- MABAC method is an effective MCDM method, because of its consistent results, ease of application, consideration of latent benefits and losses,

and ability to integrate other approaches. We need to use this approach for these reasons. Other MCDM methodologies are used to specify the performance of the proposed approach.

- A detailed experimental analysis proved the consistency of the proposed method and the efficiency of the results.

The remainder of this study is organized as follows. Section 2 includes the methodology. The case study is presented in Section 3. Result validation is discussed in Section 4 and the conclusion is presented in that last part.

2. METHODOLOGY

2.1. Financial Performance Evaluation

One of the goals of organizations in a competitive and worldwide economy is to be first among their competitors. Financial performance assessment of firms is used to rank them. Financial ratios are produced using data from an organization's balance sheet and income statement to calculate financial performance. A ratio is a mathematical expression of the connection between two data points in financial statements. Using the financial data in the financial statements, ratio analysis allows you to get more precise information about the organizations. Financial ratio analysis is used to determine the current state of a company and to establish a business strategy.

There are various measures utilized by researchers to evaluate the financial performance of firms operating in different sectors (e.g., Ginevičius and Podvezko, 2006; Wang, 2008; Wu et al., 2009); however, in this study, the most commonly used twelve financial ratios for energy companies are used based on the suggestions of the previous relevant works (Drake & Fabozzi, 2010) and the judgements of the research team. Liquidity ratios such as the current ratio (CR), acid test ratio (ATR), and cash ratio (CAR) provide information on the relationship between a company's short-term debts and current assets. The financial structure of an organization is shown by the debt ratio (DR), current liabilities to total assets ratio (CLTAR), and non-current liabilities to total assets ratio (NCLTAR). These ratios demonstrate the company's ability to pay its debts. The Asset Turnover (AT), Equity Turnover (ET), and Working Capital Turnover (WCT) ratios are used to depict the organization's asset utilisation. These ratios demonstrate the company's capacity to use its assets efficiently and successfully. The business's ability to deliver sufficient revenue to its partners and stakeholders is assessed through net profit to total assets (NPTA), net profit to equity (NPE), and net profit (NP) ratios.

2.2. Multi-Criteria Decision Making (MCDM)

Decision-making is one of the challenges we encounter on a daily basis. Simple and complicated strategic decisions, such as what to eat, investment decisions, and enterprise strategy decisions, are examples of decision-making problems. In decision-making problems, the increasing number of alternatives and criteria complicates the problem and makes the decision-making process complex. There are two types of multi-criteria decision-making problems: multi-attribute decision-making (MADM) and multi-objective decision-making (MODM). MADM is the most extensively deployed and well-known decision-making method. It's a sort of model used in operations research. MADM's result is the selection of the best appropriate option among those described by features, as well as the classification and ranking of alternatives. The MODM technique does not provide alternatives, and there are an endless number of possibilities. For the MODM problem, a mathematical model is built, and this model gives a set of choice possibilities. Selection is included in the MODM results (Kahraman & Çebi, 2009).

There are a number of MCDM methods in the literature such as linear assignment method, techniques for order preference by similarity to ideal solution (TOPSIS), outranking methods, multiple attribute utility models (MAUT) etc. As previously mentioned, the primary goal of this paper is to evaluate the financial performance of energy firms and rank them. We examine two effective MCDM methods for this purpose: the entropy method is used to determine the criteria weights, and the multi-attributive border approximation area comparison (MABAC) method is used to choose the best energy company in the energy sector. Figure 1 summarizes the four basic steps of the evaluation procedure.

Step 1. Determine which evaluation criteria are the most essential performance indicators for the energy sector.

Step 2. Using the entropy and CRITIC methods, calculate the weights of the criteria.

Step 3. Use the MABAC methodology to arrive at the final rankings.

Step 4. To evaluate and compare the ranking results, utilize MABAC, ELECTRE, MAUT, TOPSIS, and WASPAS methods.

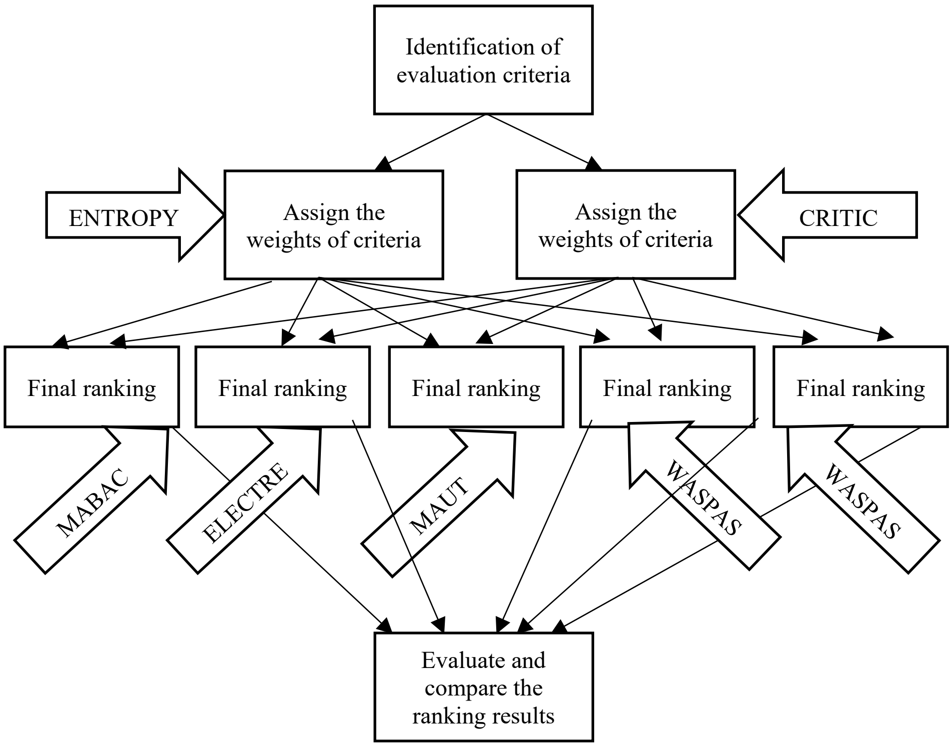

Figure 1: Steps of the Evaluation Procedure

2.3. Entropy Weight Method (EWM)

To specify the objective weights, Shannon (1948) suggested the entropy weight approach. To consider uncertain information, entropy is based on probability theory. This is an objective weighting method that uses the entropy values of each indicator to determine the indicator weights. The following are the steps for applying entropy.

Step 1: Establishing Decision Matrix

The number of *n* criteria and *m* alternatives are used to form the decision matrix. Each alternative's value for the relevant criterion is entered in the R_{ij} matrix.

$$R_{ij} = [r_{ij}]_{mxn} = \begin{bmatrix} r_{11} & \cdots & r_{1n} \\ \vdots & \ddots & \vdots \\ r_{m1} & \cdots & r_{mn} \end{bmatrix} \quad (1)$$

Step 2: Calculating Normalized Decision Matrix
For both minimization and maximization criteria, the decision matrix is normalized via equation (2).

$$e_{ij} = \frac{r_{ij}}{\sum_{i=1}^{m} r_{ij}} \quad (2)$$

Step 3: Equation 3 is used to compute the entropy values (E_j) of the criteria.

$$E_j = \frac{\sum_{i=1}^{m} e_{ij} \ln(e_{ij})}{\ln(m)} \quad (3)$$

Step 4: The following equation is used to calculate the weight of each criterions.

$$W_j = \frac{1-E_j}{\sum_{j=1}^{n}(1-E_j)} \quad (4)$$

2.4. Multi-Attributive Border Approximation Area Comparison (MABAC) Method

Pamucar and Cirovic (2015) introduced the MABAC method. In the MCDM framework, MABAC is used to solve a variety of problems (Yu et al., 2016; Shia et al., 2017; Bojanic et al., 2018). This method's primary goal is to determine the distance between each criteria and the observed alternative approximate border areas. The procedure of MABAC is given as follows:
Step 1: Establishing the decision matrix is the initial step. Equation 1 illustrates the first stage.
Step 2: Normalization is implemented to the decision matrix. Equation (5) is used to normalize benefit criteria, and equation (6) is used to normalize cost criteria.

$$d_{ij} = \frac{r_{ij} - min\,(r_i)}{max\,(r_i) - min\,(r_i)} \quad (5)$$

$$d_{ij} = \frac{r_{ij} - max\,(r_i)}{min\,(r_i) - max\,(r_i)} \quad (6)$$

Step 3: The weighted normalized matrix is generated using Equation 7.

$$b_{ij} = w_j\,(d_{ij} + 1) \quad (7)$$

Step 4: The boundary proximity area matrix is calculated by using the Equation (8).

$$g_i = \left(\prod_{i=1}^{m} b_{ij}\right)^{1/m} \quad (8)$$

$$G = [g_i]_{1xn} \quad (9)$$

Step 5: The distance matrix (Q) of the alternatives to the border closeness area is obtained by using Equation 10.

$$Q = B - G = \begin{bmatrix} b_{11} - g_1 & b_{12} - g_2 & \cdots & b_{1n} - g_n \\ b_{21} - g_1 & b_{22} - g_2 & \cdots & b_{2n} - g_n \\ \cdots & \cdots & \cdots & \cdots \\ b_{m1} - g_1 & b_{m2} - g_2 & \cdots & b_{mn} - g_n \end{bmatrix} = \begin{bmatrix} q_{11} & q_{12} & \cdots & q_{1n} \\ q_{21} & q_{22} & \cdots & q_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ q_{m1} & q_{m2} & \cdots & q_{mn} \end{bmatrix} \quad (10)$$

Step 6: The border proximity area is used to determine the locations. Equation 11 shows how to determine the lower proximity, upper proximity, and border proximity areas of the alternatives. Most qij values must be more than 0, or in other words, it must be in the upper proximity range (G^+) for an option to be the best. Alternatives that are not optimal are those that are near to the lower proximity area. That is, they are poor-performing alternatives.

$$A_i \in \begin{cases} G^+ & if\ q_{ij} > 0 \\ G & if\ q_{ij} = 0 \\ G^- & if\ q_{ij} < 0 \end{cases} \quad (11)$$

Step 7:

Summing the distance values to the boundary proximity region (q_{ij}) for each alternative provides S_i values. The alternative with the highest S_i value is determined to be the best.

$$S_i = \left(\sum_{j=1}^{n} q_{ij}\right) \quad (12)$$

3. CASE STUDY

The primary aim of the research is to use entropy and MABAC multi-criteria decision making methods to assess the financial performance of energy companies in the BIST. The scope of the study includes 8 energy companies that are traded on the Borsa Istanbul in the period 2016-2020 and whose data is regularly accessible. Annual balance sheets and income statements of companies are used. The companies included in the study's 5-year balance sheets and income statements are taken from the Public Disclosure Platform's official website (KAP). As the data for 2021 has not yet been published, it isn't possible to use it during the study's implementation stage. The following companies are included in the study's scope: Akenerji, Aksa, Aksu, Ayen, Enerjisa, Odaş, Pamukova, and Zorlu.

The study examines the financial performance of eight energy companies using twelve financial ratios. Financial ratios are a type of ratio that is used to assess a company's liquidity, asset utilization efficiency, financial structure, and profitability. The relevant literature is considered while determining the financial ratios employed in the study. These financial ratios have been determined by evaluating studies attempting to quantify the financial performance of firms with multi-criteria decision-making methods.

A decision matrix including the values of each financial ratio of energy companies for the year 2020 may be reported in Table 1. Instead of using subjective or hypothetical ways to weight the criteria, it was decided that a weighting based on the relative importance of each criterion in the total value of all criteria would be more acceptable. The decision matrix is normalized as mentioned in Equation 1 and entropy values and weights are calculated using Equations 2 and 3 as described in the entropy method steps.

Table 1: Decision Matrix Including Original Financial Ratio of Each Company

Company	CR	ATR	CAR	DR	CLTAR	NCLTAR	AT	ET	WCT	NPTA	NPE	NP
Akenerji	0,598	0,589	0,351	1,019	0,091	0,929	0,325	1,000	8,107	1,000	9,986	1,064
Aksa	1,050	1,008	0,095	0,513	0,347	0,166	0,761	19,572	59,691	1,220	1,672	1,638
Aksu	0,193	0,175	0,009	0,798	0,231	0,567	0,199	18,993	15,096	1,049	1,000	1,000
Ayen	0,344	0,344	0,121	0,738	0,178	0,560	0,171	18,661	14,702	1,131	1,437	1,385
Enerjisa	0,827	0,806	0,071	0,710	0,333	0,374	0,882	21,050	1,000	1,205	1,704	1,610
Odaş	0,467	0,292	0,014	0,769	0,324	0,445	0,286	19,246	14,507	1,089	1,239	1,307
Pamukova	1,809	1,809	1,511	0,401	0,017	0,384	0,125	18,217	25,230	1,296	1,777	2,644
Zorlu	0,494	0,485	0,091	0,893	0,375	0,518	0,401	21,743	14,053	1,163	1,568	1,565

Table 2: The Entropy Values and Weights of Each Financial Ratio

Company	CR	ATR	CAR	DR	CLTAR	NCLTAR	AT	ET	WCT	NPTA	NPE	NP
e_j	0,856	0,842	0,519	0,931	0,867	0,907	0,853	0,898	0,797	0,945	0,763	0,926
w_j	0,076	0,084	0,254	0,036	0,070	0,049	0,077	0,054	0,107	0,029	0,125	0,039

Equations 5 and 6 are applied to the decision matrix shown in Table 1. Thus, a normalized decision matrix is generated for the MABAC method. This matrix is shown in Table 3. With Equation 7, the weighted matrix is obtained. The obtained matrix is given in Table 4. With the help of Equation 8, boundary proximity matrix is created and shown in Table 5. By applying equation 12 to the matrix shown in Table 6, the results and the ranking of the alternatives can be obtained. Table 7 shows the results of year 2020.

It is undeniable that this pandemic, which broke out at the end of 2019, had some effect on organisations. The pre-pandemic period is also discussed to emphasize this influence. Figure 2 shows the rankings obtained using the proposed method to the average values for the years 2016-2019, as well as the rankings for 2020. The results clearly show that the pandemic has an impact on ranking.

Table 3: Normalized Decision Matrix

Company	CR	ATR	CAR	FLR	LDLR	SDLR	AT	ET	NWCT	RA	RE	NPR
Akenerji	0,095	0,105	0,312	0,036	0,126	0,049	0,098	0,054	0,120	0,029	0,250	0,041
Aksa	0,116	0,126	0,269	0,066	0,076	0,098	0,142	0,102	0,214	0,051	0,134	0,054
Aksu	0,076	0,084	0,254	0,049	0,098	0,072	0,085	0,101	0,132	0,034	0,125	0,039
Ayen	0,083	0,092	0,273	0,053	0,109	0,073	0,082	0,100	0,132	0,042	0,131	0,048
Enerjisa	0,106	0,116	0,264	0,055	0,078	0,085	0,155	0,106	0,107	0,049	0,135	0,054
Odaş	0,089	0,090	0,255	0,051	0,080	0,080	0,094	0,101	0,131	0,038	0,128	0,046
Pamukova	0,152	0,167	0,508	0,073	0,140	0,084	0,077	0,099	0,151	0,058	0,136	0,078
Zorlu	0,090	0,099	0,268	0,044	0,070	0,075	0,106	0,108	0,131	0,045	0,133	0,052

Table 4: Weighted Normalized Matrix

Company	CR	ATR	CAR	FLR	LDLR	SDLR	AT	ET	NWCT	RA	RE	NPR
Akenerji	0,251	0,253	0,228	0,000	0,795	0,000	0,265	0,000	0,121	0,000	1,000	0,039
Aksa	0,531	0,510	0,058	0,819	0,078	1,000	0,840	0,895	1,000	0,743	0,075	0,388
Aksu	0,000	0,000	0,000	0,358	0,403	0,475	0,099	0,867	0,240	0,167	0,000	0,000
Ayen	0,093	0,103	0,075	0,455	0,550	0,484	0,061	0,851	0,233	0,443	0,049	0,234
Enerjisa	0,392	0,386	0,041	0,500	0,110	0,727	1,000	0,967	0,000	0,693	0,078	0,371
Odaş	0,170	0,071	0,003	0,405	0,143	0,635	0,214	0,880	0,230	0,300	0,027	0,187
Pamukova	1,000	1,000	1,000	1,000	1,000	0,714	0,000	0,830	0,413	1,000	0,086	1,000
Zorlu	0,186	0,190	0,054	0,205	0,000	0,539	0,365	1,000	0,222	0,550	0,063	0,344

Table 5: Boundary Approximate Area Matrix

	CR	ATR	CAR	FLR	LDLR	SDLR	AT	ET	NWCT	RA	RE	NPR
g_i	0.099	0.107	0.292	0.052	0.094	0.076	0.102	0.094	0.137	0.042	0.143	0.050

Table 6: Approximate Border Area Matrix

Company	CR	ATR	CAR	FLR	LDLR	SDLR	AT	ET	NWCT	RA	RE	NPR
Akenerji	-0,004	-0,003	0,020	-0,016	0,032	-0,027	-0,004	-0,040	-0,017	-0,013	0,107	-0,010
Aksa	0,018	0,019	-0,024	0,014	-0,019	0,022	0,041	0,008	0,077	0,008	-0,008	0,004
Aksu	-0,023	-0,024	-0,038	-0,003	0,004	-0,003	-0,017	0,006	-0,004	-0,008	-0,018	-0,011
Ayen	-0,016	-0,015	-0,019	0,001	0,014	-0,003	-0,020	0,005	-0,005	0,000	-0,012	-0,002
Enerjisa	0,007	0,009	-0,028	0,002	-0,016	0,009	0,053	0,012	-0,030	0,007	-0,008	0,003
Odaş	-0,010	-0,018	-0,037	-0,001	-0,014	0,004	-0,008	0,007	-0,006	-0,004	-0,014	-0,004
Pamukova	0,053	0,060	0,216	0,020	0,046	0,008	-0,024	0,004	0,014	0,016	-0,007	0,028
Zorlu	-0,009	-0,008	-0,024	-0,008	-0,024	0,000	0,004	0,013	-0,006	0,003	-0,010	0,002

Table 7: Distances of Alternatives from the Boundary Proximity Area Matrix

Company	S_i	Rank
Akenerji	0,025	3
Aksa	0,159	2
Aksu	-0,139	8
Ayen	-0,072	6
Enerjisa	0,019	4
Odaş	-0,105	7
Pamukova	0,434	1
Zorlu	-0,068	5

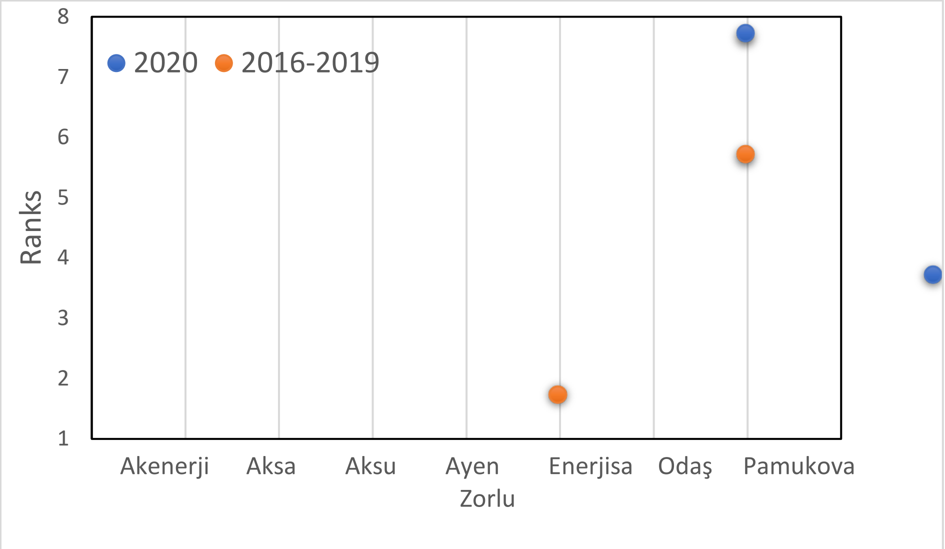

Figure 2: Ranking Obtained from Data of 2016-2019- 2020

4. RESULT VALIDATION

The validation of the acquired results is conducted in this section of the paper. A sensitivity analysis includes two phases is conducted to depict the stability of the proposed method. In the first stage, the effect of the criteria weights on the final ranking is investigated. In the second stage, the stability of the proposed approach is confirmed by comparing the results of other MCDM methods with the results of the proposed approach.

4.1. Sensitivity Analysis

The sensitivity analysis is employed to assess the impact of changing the criteria weights on the final ranking of alternatives. Sensitivity analysis reveals how the change of criterion weights in the proposed approach affects the final ranking of energy companies. For the analysis of the change in the weights of 12 criteria, the criteria are changed in pairs each time. Therefore, sensitivity analysis includes a maximum of 66 possible interchanges in criteria weights. Figure 3 shows the results of the sensitivity analysis hinge on changing criteria weights. The changing the criterion weights has a small effect on the ranking of the energy companies, and the ranking of the energy companies is virtually unchanged.

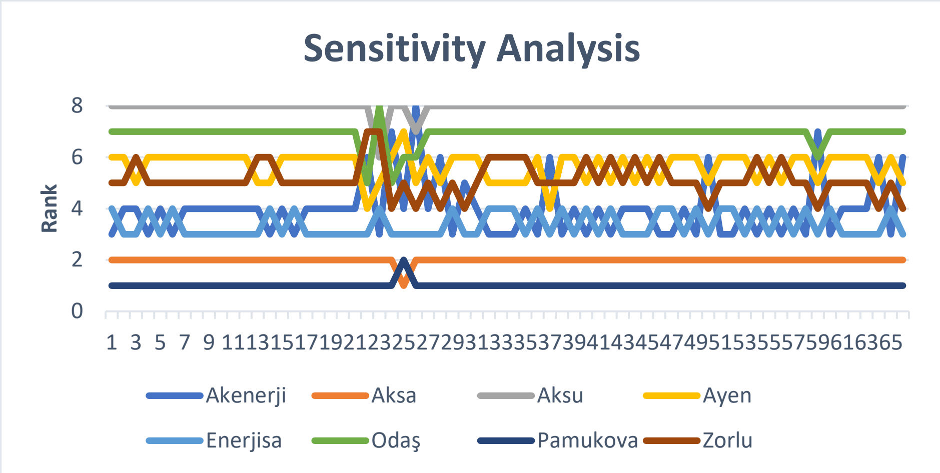

Figure 3: The Results of Sensitivity Analysis Hinge on Changing Criteria Weights

4.2. Spearman's Correlation Coefficient

In order to verify the stability of the proposed approach, other MCDM methods are applied and the proposed approach is compared with other methods. The comparison is made with Elimination Et Choix Traduisant la Realité (ELECTRE) (Giard & Roy, 1985), Multi Attribute Utility Theory (MAUT) (Keeney et al., 1993), TOPSIS (Hwang & Yoon, 1981), and Weighted Aggregated Sum Product Assessment (WASPAS) (Zavadskas et al., 2012). The results are shown in Table 8. Spearmans' correlation coefficient is utilized to represent the relationship between different types of MCDM rankings obtained as a result of the applications of ELECTRE, MABAC, MAUT, TOPSIS and WASPAS methods. These coefficients have an importance close to 1 if observations have similarities in the rankings. Table 9 shows the meaning of these values for Spearman's correlation coefficient (Keshavarz-Ghorabaee et al., 2020). The values of Spearman's correlation coefficient, which demonstrate the correlation between different types of MCDM methods are given in Table 10. As can be seen in this table, all the coefficient values are greater than 0.9, so the relationship between different types of MCDM is strong.

The different weighting method is employed to analyze the effects of the weighting method on the final alternative rankings. The CRITIC method, which is another objective method without individual personal assessment and allocates the index weights based on the information of the indices and the correlation between them, is applied. The weighting method has been utilized to other

MCDM methods and the rankings are presented in Table 11. The values of Spearman's correlation coefficient for each MCDM method with two weighting methods are greater than 0.8, so the relationship between different types of MCDM is strong. Therefore, we can conclude that the results of the financial performance comparison are stable and the proposed approach can be employed for logical decision making for the financial performance evaluation of alternative companies in the energy industry.

Table 8: Different Types of MCDM Methods Rankings Based on Entropy Method

Company	MABAC	ELECTRE	MAUT	TOPSIS	WASPAS
Akenerji	3	3	3	2	3
Aksa	2	2	2	3	2
Aksu	8	8	8	8	8
Ayen	6	5	6	6	6
Enerjisa	4	4	4	4	4
Odaş	7	7	7	7	7
Pamukova	1	1	1	1	1
Zorlu	5	6	5	5	5

Table 9: Interpretation of Spearman's Correlation Coefficient

Coefficient range	Relationship interpretation
$\rho \geq 0.8$	Very strong
$0.6 \leq \rho < 0.8$	Strong
$0.4 \leq \rho < 0.6$	Moderate
$0.2 \leq \rho < 0.4$	Weak
$\rho < 0.2$	Very weak

Table 10: The Results of Spearman Correlation Application

Variable	Electre	Mabac	Maut	Topsis	Waspas
Electre	1,000	,976**	,976**	,952**	,976**
Mabac	-	1,000	1,000**	,976**	1,000**
Maut	-	-	1,000	,976**	1,000**
Topsis	-	-	-	1,000	,976**
Waspas	-	-	-	-	1,000

$^{*}p < .05$. $^{**}p < .01$. $^{***}p < .001$

Table 11: Different Types of MCDM Methods Rankings Based on Critic Method

Company	MABAC	ELECTRE	MAUT	TOPSIS	WASPAS
Akenerji	4	5	7	1	4
Aksa	2	2	2	3	2
Aksu	8	8	8	8	8
Ayen	5	6	4	6	6
Enerjisa	3	3	3	4	3
Odaş	7	7	6	7	7
Pamukova	1	1	1	2	1
Zorlu	6	4	5	5	5

5. CONCLUSIONS

In recent years, it has emerged as one of the fastest-developing industries at the international level in the context of the developments in the energy industry and its relations with other industries. With the advances in the energy sector, a precise attention can be paid to the financial performance evaluation of the companies in order to evaluate their efficiency. Thus, managing the financial performance of companies has been considered a significant topic in many papers.

In this paper, we suggest a novel hybrid MCDM method that includes Entropy and MABAC methods to investigate the financial performance of energy companies in Turkey. The weight of each criterion is calculated using the entropy method. In the solution of the problem, it is aimed to obtain a ranking by using MABAC method. The data are collected from the official website of the Public Disclosure Platform. The data for 2020 and 2016-2019 are handled as two separate groups. The experimental results show that Pamukova is the best, and Aksu is the worst among energy companies considering financial ratios for 2020 based on the proposed MCDM. The ranking of results pre-pandemic and post-pandemic shows the impact of the pandemic on organization efficiency. The most important three factors for the evaluation of financial performance are Cash Ratios, Return on Equity, Net Working Capital Turnover, respectively.

In order to verify the performance of the proposed approach, result validation is performed. Firstly, the effect of changes in criterion weight and different criterion weighting method on the final ranking are examined. The sensitivity analysis shows that the changes in results are not significant when criteria weights and the criteria weight assignment method vary. Secondly, the results of the proposed approach are compared with other MCDM methods (ELECTRE, MAUT, TOPSIS, WASPAS). The results of validation experiments confirmed that the proposed approach is consistent and feasible. Overall, we conclude that the proposed approach can be considered an efficient MCDM to cope with evaluation problems. The proposed approach can be applied to different types of decision making problems.

6. CONFLICT OF INTEREST STATEMENT

There is no conflict of interest between the authors.

7. FUNDING ACKNOWLEDGEMENTS

No funding or support was used in this study.

8. AUTHOR CONTRIBUTIONS

The authors contributed equally.

9. ETHICS COMMITTEE STATEMENT AND INTELLECTUAL PROPERTY COPYRIGHTS

Ethics committee principles were followed in the study. No permission was required within the scope of intellectual property and copyrights.

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