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RESEARCH ARTICLE

COMPARISON OF THE FINANCIAL PERFORMANCES OF THE COMPANIES OPERATING IN THE RENEWABLE ENERGY SECTOR TRADING IN BORSA ISTANBUL WITH THE ENTROPY BASED TOPSIS METHOD

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Abstract

The financial performance analysis of the companies operating in the energy sector is an important indicator for the countries. Especially with the renewable energy sector gaining importance, the most basic way for companies in the renewable energy sector to be successful and ensure their continuity is to pay attention to their financial performance management and take a role in the global market. It is very important for companies to determine the status of their financial performance. Because of this situation, companies use ratio analysis, one of the methods used in the analysis of financial statements, in order to determine the status of their financial performance. It is used to determine the significant relationships between the accounts in the financial statements with the ratio analysis technique. In this method, mathematical relations are established between accounts or groups of accounts. With the results obtained with mathematical relations, it is tried to reach a judgment about the economic and financial structure of the enterprise. The aim of this study is to examine 8 companies operating in the energy sector in Turkey and operating in renewable energy sources among the companies registered in Borsa Istanbul (BIST). Using ratio analysis, one of the financial analysis methods, the financial statements of 8 companies for 2020, 2021 and 2022 is examined. Their financial performance, liquidity, leverage, operations and profitability is examined. The reason for choosing the 2020 period is that financial statements are accessible, and the number of companies in the renewable energy sector is at its maximum level. In the first chapter, energy and energy resources are defined, and the energy sector in the world and in Turkey is examined. In addition, similar studies in the literature are included in this section. In the second part, financial performance analysis and its methods are mentioned, and the multi-criteria decision-making method is mentioned. In the third part, their financial performances are analyzed and interpreted using the ratio analysis method. After these processes, the criteria are weighted objectively with Entropy methods,and then the companies are ranked according to their performances by making use of the distances from the ideal solution with TOPSIS, one of the multi-criteria decision-making (MCDM) methods. In the last part, the findings obtained as a result of the application are presented, and in the conclusion part, evaluations are made and interpreted.

Keyword

Renewable Energy, Financial Performance, Entropy,

TOPSIS

1. Introduction

Energy is among the most basic human needs. In today's conditions, the amount of energy consumption per capita in a country has become a measure of development among countries. The most important reasons for the increase in the said energy requirement are developments in technology and population growth. The discovery of energy resources and ensuring the continuity of these resources are constantly on the world

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agenda. In an economy, energy is considered a basic input. On behalf of a country, it is very important that the energy used is cheap, sufficient to meet the need, safe, and of high quality (Çoşkun, 1982). Its importance in the economic situation of the country, its role in the production processes, the rate of use of technology, and scientific approaches on the subject are once again understood.

In today's world, high demand for energy has made energy resources insufficient to meet this need. The disproportionate relationship between these two variables brought up the necessity of efficient use of energy resources and has become a common problem in all world economies. With increasing public awareness, the harm caused by fossil fuel-based energy supply to the environment has been known to everyone, and the tendency to use renewable energy sources that provide clean energy has increased with the development of technological developments. The main ones are solar, wind, biomass, and geothermal energy. The use of sun and wind has increased considerably in recent years due to the fact that they do not contain raw materials and that almost every country has them. In order to encourage its use, country governments have also introduced some legal regulations, such as tax reductions and purchase guarantees for the produced energy. As renewable energy sources have become important for countries, they have also gained an important share in the academic community in recent years. The studies carried out may be to measure or evaluate the success of countries in using renewable energy sources, as well as to develop the technology used in obtaining this energy.

The energy market consists of a wide range of market activities, starting with exploration and production, including refining, transmission, storage, distribution, and trading. While exploration and production activities for energy resources are called upstream markets, refining, transmission, storage, distribution, and marketing activities are called downstream markets (Ergül, 2015). Energy markets are markets where economies of scale and scope are valid, and government support is needed from time to time, especially in terms of international investments. Since the energy industry is a sector where large-scale and capital-intensive investments are made, companies operating in the sector create great economic power and play an active role in determining strategies and policies at both the national and international level. Countries with rich energy resources want to use these resources in a way that will provide the highest income, while countries that are importers want to reach their energy resources in the most cost-effective way. For this reason, one of the important factors that constitute the characteristics of the market is the characteristics of the countries in shopping (Bayraç, 2009). There is a delicate balance between supply and demand in energy markets. Since the demand for energy cannot make big jumps in normal conditions, there is generally a plan for production in terms of controlling energy prices. The price of energy, which is one of the basic inputs of the economy, is one of the important indicators of the general economic conjuncture, and the higher and longer the increase in energy prices, the longer and longer the effects on the macro economy (Pamir, 2003). For sustainable economic growth, it is vital to provide energy from reliable sources uninterruptedly and at affordable costs. In the world economy, many countries' desire to own and/or control energy resources, especially oil and natural gas, makes energy an indispensable political tool at the same time.

In the first part of this study, the definition of the renewable energy sector is given. In the second part, related explanations are given about the concept of MCDM. In the rest of the section, formulas on how to calculate the Entropy and TOPSIS methods used in the study are shown. In the third part, the relevant literature review is made about other studies. In the literature review stage, the studies in the energy sector and the studies on applied MCDM methods are examined. In the study, the financial performance of 8 companies operating in the energy sector, whose shares are traded in BIST, between the years 2020 and 2022 is determined by the TOPSIS methods, which are MCDM methods, which are Entropy weighting methods. The determined success order has been made.

2. Literature Review

Due to problems such as the tendency of fossil resources to be depleted and greenhouse gas emissions worldwide, studies are carried out to ensure the effective use of existing resources and to use renewable energy resources. The costs of energy resources are constantly changing due to developments in technology and political reasons. Many countries are following the energy sector carefully in order to have energy at lower costs and continuously. In addition, many countries are struggling to be the pioneers of changes in the sector in order to have a greater say in this field.

Energy is an indispensable actor in daily life, which is at the core of life. The fact that energy is at the heart of industry as well as its vital function increases its value even more. However, due to the limited energy resources and the effects it has on the environment, apart from the benefits it provides to individuals, it also comes to the fore as a political element. How this balance between economic development and energy consumption should be achieved will be answered by the policies that governments and experts are produce on this issue. Energy efficiency policies are one of the areas that need to be handled sensitively because of their direct relationship with the sustainability of economic growth and social development goals on the one hand and the key role they play in reducing total greenhouse gas emissions on the other. In this context, many studies have been carried out in recent years on energy consumption, sustainable energy resources, and energy efficiency. Henryson et al. (2000) analyzed the link between energy efficiency and energy structure and found a remarkable correlation between the exchange rates between coal and oil. Hepbasli and Utlu (2004) studied Turkey's renewable energy resources, efficient use of these resources, and policies that can be developed on this issue. The clean energy needs of countries and the necessity of meeting this need at a sufficient level have become a problem both for the economy and for the citizens. Therefore, effective and efficient use of energy resources is of great importance for countries. The fact that there is an indispensable relationship between energy and almost all fields of activity in the economy today indicates that there is a close relationship between energy use and economic growth. However, the intensity of this relationship differs from country to country. While the relationship between energy demand and economic growth in developing countries is extremely strong, it is seen that the said relationship is weaker in developed countries. In other words, the elasticity coefficient between energy consumption and GNP growth is generally lower than 1 in developed countries and higher than 1 in developing countries (Saatçioğlu and Küçüksoy, 2004). The energy sector, which stands out as a supportive and necessary resource among all sectors, gains importance in parallel with the growth of the world economy and is in a position to affect the industries, environment, and global strategies of countries. Countries give special importance to the energy sector in order to grow economically. The availability of limited resources and the increase in demand day by day carry the energy sector to a critical point (İskenderoğlu et al., 2015). The energy sector directly concerns other sectors and supports the welfare and economic growth of countries. Energy has a very important place in the development of states (Aktaş and Alioğlu, 2012). Obtaining energy at low costs within the country is very important in order to be one step ahead in the competitive environment in the international market. At this stage, it is not only important that the energy source potential is high. In addition, the quality of energy, transportation possibilities, storage methods, distribution, and technological possibilities are important. Having technologies that will enable the transformation of energy types among themselves and ensuring the continuous development of these technologies contributes to the effectiveness of energy policies. Having energy does not mean only having energy resources.

The gradual increase in energy demand causes priority to be given to supply, not nature, in meeting the increasing energy demand. However, developed countries are looking for ways not to harm nature as well as the supply of this work. For this, they are looking for new technologies and new renewable energy sources. New technologies aim to bring efficient and lower-cost electricity generation from currently used energy types. Increasing energy prices in energy-importing countries creates an inflationary effect by increasing production costs. While the rising energy import bill directs governments toward contractionary fiscal policies, the resulting inflationary pressure causes general demand to be curtailed. The decrease in public and private sector expenditures leads to economic stagnation and unemployment. These negative effects are growing exponentially, as rising prices and the current economic recession have shaken confidence in consumer markets. On the other hand, increases in oil prices cause countries to take measures to reduce energy intensity by focusing on research and development activities and on renewable energy investments (Aydın, 2010).

In the concept of renewable energy, countries that do not have underground resources also have a much greater potential for energy production opportunities that can provide energy continuity from water, sun, wind, geothermal heat, animal waste, household waste, and similar sources. Turkey's share of renewable energy generation is quite low compared to its potential. With the geopolitical position of the country and the climatic advantages where all seasons can be experienced, it provides more effective environmentalist renewable energy investments. Renewable energy sources represent uninterrupted annual energy flows. It has the potential to meet global energy needs. However, it is often difficult to manage low or variable energy densities and not have sufficient technology to enable interruptions and convert them into usable fuels (Rogner, 2012).

Turkey's geostrategic location makes it a reliable and sustainable route between the energy producing countries in the Caspian and Middle East and the countries in need of energy. For this reason, Turkey provides the necessary support to large-scale energy projects in order to ensure the safety of energy transmission lines and to pass over them. Turkey, taking firm steps forward to become the commercial center of energy, allocates resources to joint energy projects in a win-win relationship as a bridge to energy-producing and energy-needing countries and makes diplomatic attempts to cross these lines through bilateral agreements. Turkey increases its energy imports every year to meet the increasing energy needs of its rapidly growing economy. Due to its increasing energy demand, Turkey supplies one-fourth of its energy from domestic sources and the rest from outside. It is seen that this energy need will continue in the following years (Şahin and Şahin, 2018). Turkey, which does not want to be dependent on imported energy, accelerates its domestic energy investments. Altay Topçu (2019) emphasizes that studies and investments that are reduce foreign dependency on energy and utilize domestic opportunities are support the healthy growth of Turkey. Turkey has important potential in terms of renewable energy resources. According to Ertürk (2019), our country has low reserves in terms of some fossil resources. However, it was stated that the country is very lucky in terms of renewable energy sources.

In the literature, there are various studies in which decision-making methods are used in the financial performance analysis of electricity generation companies. Dikbıyık (2015) analyzed the financial statements of companies in the energy sector between the years 2009 and 2013. As a result of the study, the items that cause the detrimental results of the activities of the companies in 29 sectors are explained. It was stated that the current assets of the companies in the energy sector were insufficient to pay their short-term debts, and it was mentioned that foreign resources were emphasized. Eyüboğlu and Çelik (2016) evaluated the 2008–2013 period data of 13 energy companies traded in Borsa Istanbul according to the criteria of liquidity, activity, financial leverage, profitability, and growth rates. The weights of the ratios were determined by Fuzzy AHP and then the Fuzzy TOPSIS method was used to rank the energy companies. The ranking of the criteria according to their weights is liquidity and profitability, growth rate, financial leverage ratio, and activity ratio.

Shin et al. (2016) wanted to examine the relationship of renewable energy use with financial performance over time, covering the years 2007–2013. As a result of their research, it has been determined that the use of renewable energy has a positive effect on financial performance. Sağır and Doğanalp (2016), in their study, used an indefinite multi-criteria decision-making method to process various resources that Turkey has use in energy production. Here, the target is to determine the importance of the decision-making elements by means of the uncertain TOPSIS method in order to determine and evaluate the options available in the energy field, and to examine and evaluate the energy resources in the light of these decision-making elements. The three energy sources discussed in the study were as follows: fossil, renewable, and nuclear energy. Şahin and Saygılı (2018) applied the TOPSIS method to 21 companies operating in the soil-based sector traded in the BIST between 2009-2016 and compared them according to their stock prices. As a result, it has been determined that there is no parallelism between TOPSIS ranking and stock prices. Metin et al. (2017) analyzed the financial data of 11 energy companies traded in the BIST with TOPSIS and MOORA multivariate decision methods. The financial statements of the companies for the 5-year period between 2010-2015 are discussed. First, the financial ratios of the companies were determined, and then the financial data of energy companies were reduced to a standard value with the MOORA and TOPSIS methods based on these ratios. In both methods, financial data revealed different values. 66 different rankings were made through MOORA and TOPSIS, and only 3 companies had the same performance order. According to another result of the study, there is no company that draws the best or the worst graph in the performance rankings as of the examined period. Öztel, Aydın, and Köse (2018) evaluated the corporate sustainability performance of an electricity generation company (Akenerji) operating in Turkey between 2010 and 2016 according to 14 criteria in terms of economic, environmental, and social impacts, using Entropy and TOPSIS methods. Bağcı and Yiğiter (2019) compared the financial performances of 15 energy companies traded in Borsa Istanbul between 2008 and 2017 in terms of 16 criteria using SD (standard deviation) and WASPAS methods. According to the results of this study, Orge Energy has the highest performance, and Akenerji has the lowest performance. Karakul and Özaydın (2019) evaluated the financial performances of 8 electricity generation companies registered in Borsa Istanbul in terms of seven criteria using TOPSIS and VIKOR methods. In the study, Aksa Energy and Enerjisa companies are at the top in terms of financial performance, while Akenerji, Aksu Energy, and Bomonti Electric companies are at the bottom. Bağcı H., Yiğiter Ş.(2019), in the study, the financial performances of energy companies registered in BIST between 2008 and 2017 were analyzed with SD and WASPAS methods, which are multi-criteria decision making methods. In the results of working; it has been stated that the WASPAS method gives more reliable results, and the companies with the best and worst performance in the energy sector are specified. Avcı Can (2019) analyzed the performance analysis of companies operating in the energy sector with the MOORA and ARAS methods, one of the MCDM methods, to reach the company ranking and compared the achieved ranking with the Fortune-5002016 ranking. As a result of the study, it is seen that the list order reached by MCDM methods and the list order that he compares are different from each other. Orçun (2019) evaluated the financial performances of 5 electricity generation companies traded in Borsa Istanbul for the years 2016 and 2017 according to 8 criteria using Entropy and WASPAS methods. Ayen Energy is the company with the highest performance in both years. Aksa Energy had the lowest performance in 2016, and Zorlu Energy in 2017. Kara (2019) analyzed the financial performance of companies in the energy sector traded on the stock exchange between 2012 and 2018. It fulfilled 9 criteria with the AHP and TOPSIS methods. While the rankings of the companies did not change much over the years, sudden ups and downs were observed in the rankings of Aksu and Odas. Ağ and Kuloğlu (2020) examined the 2019 performances of energy companies in Borsa Istanbul, with the help of the Data Envelopment Analysis (DEA) method. According to the results of this study, Akenerji, Aksu Energy, Ayen Energy, Enerjisa Energy, and Zorlu Energy companies are the companies with the highest performance. Çiftçi and Yıldırım (2020) analyzed the financial performances of 6 energy companies in Borsa Istanbul between 2011 and 2019 in terms of 20 criteria with the help of the Gray Relational Analysis Method and the Gray Entropy Method. The study findings showed that Aksa Energy had the highest performance, while Zorlu Energy had the lowest. Işık and Koşaroğlu (2020), using SD and MAUT methods, evaluated the financial performances of 5 oil companies in Borsa Istanbul between 2010 and 2019 by considering 8 criteria. They are found to be the company with the highest performance. Kara and Uslu (2020) compared the relative performances of 21 electricity distribution companies operating in Turkey between 2013 and 2018 using the non-parametric Data Envelopment Analysis (DEA) method. Karcıoğlu, Yalçın and Gültekin (2020) used Heuristic Fuzzy Logic and Entropy methods with 13 criteria to analyze the financial performances of 8 energy companies in Borsa Istanbul between 2013 and 2017. While the best performing companies were Odaş and Aksu Energy, the worst performing companies were Aksa Electric and Ayen Electric. Kuvat and Güler (2020) analyzed the financial performances of 8 energy companies traded in Borsa Istanbul between 2014 and 2017 in terms of 10 criteria using the fuzzy TOPSIS method. According to this study, Enerjisa and

Odaş companies ranked at the top in terms of financial performance in all years, while Bomonti Electric took the last place. Mercan and Çetin (2020) evaluated the financial performances of 7 electricity generation companies in the Borsa Istanbul Electricity Index between 2014 and 2018 according to 5 criteria using the COPRAS and VIKOR methods. According to both methods and all years, Enerjisa company is in the top place in terms of financial performance, while Akenerji and Zorlu are in the last place. Yenioğlu and Toklu (2021) compared the performances of 21 electricity distribution companies operating in Turkey between 2011 and 2016 with the help of Stochastic Data Envelopment Analysis. In their study, Büyükarıkan and Eryılmaz (2020) analyzed the financial performances of 4 agricultural companies operating in the BIST using 2012 and 2013 data using the DuPont analysis method. According to their results, there is a significant relationship between active capital and return on investment. Topal (2021), in his study, carried out the financial performance evaluation of 10 electricity generation companies on the Forbes 500 list with the entropy-based CoCoSo method. As a result of the study, companies were ranked according to financial performance. According to Rastogi et al. (2021), financial performance measurements of renewable energy companies in India and the USA between the years 2015-2019 were measured with ROE, and their performance trends are investigated using the k-mean algorithm. In addition, the factors affecting financial performance are tried to be explained by economic policies. As a result of the research, they determined that changes in government regulations and tariff policies are common factors in determining the future of the firm. In addition, it are concluded that tariffs and policies for renewable energy companies should be framed in a way that encourages companies to increase their investments in clean energy generation.

3. Research Methodology

In the literature review, the financial analyses of the companies in the energy sector are mostly made, but the financial analyses of the companies in the renewable energy sector are not particularly encountered in the Turkish literature. This study is aimed at revealing the financial structure of the companies in the renewable energy sector, which is becoming increasingly important, to analyze and interpret their performance. Valuation, from a financial point of view, can be considered a factor that determines the performance of a firm's activities. When considered from this point of view, valuation has the ability to influence the decisions of financial investors in estimating the firm's value in market conditions as close to the truth as possible. Therefore, this process is a helpful element in calculating the success and failure of the business, the performance measurement of employees and managers, and the tax accrual of the tax to be paid to Chartered Accountants in England Wales (ICAEW, 2018). With a wider scope, the purpose of valuation is to calculate the monetary amounts of the assets and liabilities of a firm and the results of its activities over a certain period of time in the most realistic way possible (Baktöre et al., 2000).

By using all the financial statements of the companies with renewable energy sources in the field of activity for the year 2020-2022, among the companies registered in Borsa Istanbul (BIST) serving in the energy sector in Turkey, their financial structures are examined, and their financial performances are analyzed and interpreted. The analysis is carried out by using the financial statements of 8 companies operating in the renewable energy sector, whose shares are traded in BIST, for the years 2020-2022. The selection of companies is based on their energy production based on renewable energy sources. The reason for choosing the 2020 period is that the number of companies in the renewable energy sector that can access financial statements is at the maximum level.As renewable energy sources; solar, hydroelectric, wind, geothermal, biomass, and wave energy are covered. The application data was accessed via the Public Disclosure Platform (KAP). The aim of this study is to analyze the financial structure, liquidity, activity (effectiveness), and profitability for the years 2020–2022, using the ratio analysis method, which is a type of financial analysis, on energy companies whose stocks are traded in Borsa Istanbul (BIST) to reach the success rankings by considering them in the meantime. When the table is examined, it is seen that 8 companies are included in the scope of the research.

Table 1: List of Companies Analyzed

Row number	BIST	Trade Name
1	AKENR	AKENERJI ELECTRICITY GENERATION INC.
2	AKSUE	AKSU ENERGY AND TRADE INC.
3	AYEN	AYEN ENERGY INC.
4	ENJSA	ENERJISA ENERGY INC.
5	NATEN	NATUREL RENEWABLE ENERGY TRADE INC.
6	PAMEL	PAMUKOVA RENEBABLE ELECTRICITY GENERATION INC.
7	YAYLA	YAYLA ENERGY PRODUCTION TOURISM AND CONSTRUCTİON TRADE INC.
8	ZOREN	ZORLU ENERGY ELECTRICITY GENERATION INC.

In the study, the TOPSIS method is chosen from the MCDM methods. The MCDM process consists of four stages: defining the problem, determining the alternatives and comparison features, or, in other words, determining the criteria, determining the appropriate solution method for the problem, and completing the decision-making process by evaluating the results (Kentli and Kar, 2011). The MCDM method preferred in practice is TOPSIS, the details of which are given in the next section.The reason for choosing this method is that its applicability is easy and it is one of the most basic methods. TOPSIS logic is based on the selected alternative having the shortest geometric distance from the best solution and the longest geometric distance from the worst solution. With this method, a criterion with low performance creates a trade-off balance with good performance in another criterion, allowing compromises between the criteria. Moreover, since the negative and positive ideal solutions are determined with TOPSIS, it is a feature that distinguishes it from other MCDM methods in that it can be interpreted according to their ideality among the alternatives to be selected. Multi-criteria decision analysis, according to Langemeyer et al. (2016), is a multi-step process consisting of a set of methods for structuring and formalizing decision-making processes in a transparent and coherent manner. When there are many alternatives for solving a problem, it is important to find the most suitable alternative with the best cost criteria, the lowest environmental impact, and good energy efficiency. In such a case, multi-criteria decision analysis methods are used to compare alternatives (Zlaugotne et al., 2020). The criteria weights are determined by the Entropy method, and the ranking was carried out with TOPSIS. It is thought that the result to be reached will be a resource that can give ideas to investors and other researchers interested in this subject.

The financial performances of the enterprises, which are the subject of the study, are tried to be determined by using the TOPSIS method, and the Microsoft Office Excel program was used in the solution of the model. Within the scope of the application, a total of 14 decision criteria (financial performance ratio) and 8 decision alternatives (firm) are discussed.

Table 2: Ratios Used in Financial Performance Analysis

Ratio Type	Ratio Name	Calculation	Ideal Value
Liquidity Ratios	Current Ratio	Current Assets / Current Liabilities	Benefit
	Acid-Test Ratio	Current Assets – Inventories / Current Liabilities	Benefit
	Cash Ratio	Cash And Cash Equivalents / Current Liabilities	Benefit
Leverage Ratios	Financial Debt Ratio	Total Debt/Total Assets	Cost
	Leverage Ratio	Total Debt/EBITDA	Cost
Efficiency Ratios	Asset Turnover Ratio	Net Sales / Average Total Assets	Benefit
	Receivables Turnover Ratio	Net Credit Sales / Average Accounts Receivable	Benefit
	Inventory Turnover Ratio	Cost Of Goods Sold / Average İnventory	Benefit
	Equity Turnover	Annual Net Sales / Average Stockholders' Equity	Benefit
Profitability Ratios	Return On Assets Ratio	Net İncome / Total Assets	Benefit
	Gross Profit Margin	Gross Profit/ Revenue	Benefit
	EBITDA Margin	EBITDA / Sales Revenue	Benefit
	Net Profit Margin	Net İncome/Revenue	Benefit
	Return On Equity Ratio	Net İncome / Shareholder's Equity	Benefit

In order to carry out the analysis with the TOPSIS multi-criteria decision making method in the study, the importance degrees of the financial performance ratios, which are determined as criteria in the decision problem, are weighted with the Entropy method.

a. Entropy

In MCDM methods, the weighting of the criteria is generally carried out in two ways. Among these weighting methods, subjective weighting includes the evaluations of the decision-maker, while objective weighting includes the quantitative features of the alternatives, and one of the objective weighting methods is the Entropy Method (Bakır and Atalık, 2018). In cases where the decision matrix data is clear, entropy is used to calculate the weight, or, in other words, to measure the amount of useful information provided by the existing information (Ömürberk et al., 2017). In this method, the smaller the Entropy value, the smaller the disorder value in the system (Yavuz and Baki, 2019). The strength of the Entropy Method is that it provides a more objective and clear analysis by considering the information about the alternatives without the need for the evaluations of the decision-makers. The entropy method consists of 4 steps, as shown below (Kenger, 2017). The amount of useful information can be measured with the entropy method (Wu, Sun, Liang, & Zha, 2011).

Step 1: Creating the Decision Matrix

At this stage, the decision matrix (Equation 1), which shows the values of the alternatives according to the criteria, is created with the help of it. X_{ij}, i. j of the alternative. indicates the value of the criterion. The decision matrix includes n criteria and m alternatives.

$$D = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} x_{11} & x_{12} & & x_{1n} \\ x_{21} & x_{22} & & x_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ x_{m1} & x_{m2} & & x_{mn} \end{bmatrix}$$

Step 2: A normalized decision matrix is created with the help of Equation (2).

$$p_{ij} = \frac{x_{ij}}{\sum_{i=1}^{m} x_{ij}}, \forall\ i, j$$

Step 3: Entropy values of the criteria are found by Equation (3) and Equation (4).

$$k = \frac{1}{(\ln(n))}$$

$$E_j = -k \sum_{i=1}^{m} \left[P_{ij} \ln P_{ij}\right]$$

Step 4: Finding Degrees of Differentiation are calculated by Equation (5).

$$d_j = 1 - e_j \quad j = 1, 2, \ldots, n$$

Step 5: The criterion weights (wj) are calculated by Equation (6).

$$w_j = \frac{1 - E_j}{\sum_{i=1}^{m}(1 - E_j)}, \qquad \sum_{i=1}^{m} w_j = 1$$

Additional information:

Since the entropy method includes the logarithm function in Equation (7), it is problematic to find negative numbers in the data. To overcome this problem, some transformations have been proposed in the literature (Chang & Wang (n.d.); Zhang et al., 2014). However, there is no fully accepted method in the literature. The most important reason for this is the problem of not maintaining proportional differentiation in the data while performing the transformation. In this study, a linear normalization transformation is proposed. The following conversion is done for the values found in the negative number criterion (column) xij:

$$x'_{ij} = \frac{x_{ij} - \min_{i \in I} x_{ij}}{\max_{i \in I} x_{ij} - \min_{i \in I} x_{ij}}$$

Here max_{ij} and min_{ij} are the largest and smallest values in the criterion, respectively. With this transformation, the data will be moved to the range [0,1]. For values of 0, a very small value such as 0.00001 is assigned.

b. TOPSIS

The TOPSIS Method is a widely used method in terms of being understandable and having very good computational efficiency with its simple logic, allowing the performance of each alternative to be measured based on a simple mathematical equation, and quickly determining the best alternative with its subjective input (Wang et al., 2018). At the core of the TOPSIS approach is the idea that the most chosen alternative is not only the closest to the positive ideal solution but also the farthest from the negative ideal solution (Chang et al., 2010). The steps of the process can be explained as follows:

Step 1: Creating the Decision Matrix

The decision matrix is formed as follows and stated in Equation (8).

$$A_{ij} = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ a_{m1} & a_{m2} & \cdots & a_{mn} \end{bmatrix}$$

Step 2: Calculate value r_{ij} by calculated decision matrix

The formulation of this process is given in Equation (9) in the figure below.

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}}$$

$$(i = 1, \ldots, m \, ; \, j = 1, \ldots, n)$$

Step 3: Calculate value vij by calculating weight decision matrix.

The weighted standard decision matrix is created as stated in Equation (10).

$$v_{ij} = r_{ij} \times w_j \quad i = 1, 2, \ldots, m \text{ and } j = 1, 2, \ldots, n.$$

Where w_j is the weight of the j^{th} criterion and $\sum_{j=1}^{n} w_j = 1$.

Step 4: Determine the ideal (A^*) and negative ideal (A^-) solutions

Finding the positive and negative ideal solution set is formulated as follows as stated in Equation (11) and Equation (12).

$$A^* = \{(\max_i v_{ij} \mid j \in C_b), (\min_i v_{ij} \mid j \in C_c)\} = \{v_j^* \mid j = 1,2,\ldots,m\}$$

$$A^- = \{(\min_i v_{ij} \mid j \in C_b), (\max_i v_{ij} \mid j \in C_c)\} = \{v_j^- \mid j = 1,2,\ldots,m\}$$

Step 5: Calculate measures every alternative from the positive ideal solution and the negative ideal solution.

By means of this formula, the distance values from the maximum and minimum values of each column are calculated. This calculation is performed as follows, as indicated in Equation (13) and Equation (14), respectively.

$$S_{ij}^* = \sqrt{\Sigma_{j=1}^{n}(v_{ij} - v_j^*)^2}$$

$$S_{ij}^- = \sqrt{\Sigma_{j=1}^{n}(v_{ij} - v_j^-)^2}$$

Step 6: Calculating Relative Closeness to the Ideal Solution

The closeness value (Ci^*) to the positive ideal solution is calculated by the formula below as stated in Equation (15).

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*}$$

3.Analysis of the Research and Findings

3.1. Entropy Method

1. Creating a Decision Matrix

The first step of the Entropy method, which is one of the MCDM methods, is the creation of the decision matrix. In order to create this decision matrix, the financial ratios calculated through the financial statements of the 8 companies included in the study are calculated. With the ratio analysis method, the required 14 financial ratios are calculated for the years covering the study. The decision matrix created with the application data created by calculating through the data provided from KAP is stated by transferring to MS Excel as stated in Equation (1):

Table 3 : Financial Ratio Calculated for 2020

2020														
	Current Ratio	Acid-Test Ratio	Cash Ratio	Financial Debt Ratio	Leverage Ratio	Asset Turnover Ratio	Receivables Turnover Ratio	Inventory Turnover Ratio	Equity Turnover	Return On Assets Ratio	Gross Profit Margin	EBITDA Margin	Net Profit Margin	Return On Equity Ratio
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
AKENR	0,60	0,59	0,35	90,32	101,91	0,32	25,68	604,69	5,25	-15,94	9,06	19,29	-49,59	-260,59
AKSUE	0,19	0,18	0,03	68,16	79,76	0,20	7,92	16,97	0,77	-11,06	65,60	71,83	-56,04	-43,24
AYEN	0,34	0,34	0,12	69,18	73,80	0,19	13,96	0,00	0,70	-3,07	33,33	43,65	-16,11	-12,40
ENJSA	0,83	0,81	0,09	39,56	71,01	0,91	7,31	106,92	3,11	4,53	25,92	16,27	5,00	-208,63
NATEN	2,47	2,29	1,78	31,95	44,92	0,15	11,11	6,10	0,30	8,15	52,38	49,79	878,89	21,02
PAMEL	1,81	1,81	1,51	37,75	40,11	0,12	34,08	0,00	0,21	5,83	59,98	70,94	46,82	9,73
YAYLA	0,55	0,53	0,24	33,57	41,27	0,09	3,61	22,61	0,16	-3,35	-37,97	-50,43	-35,44	-5,51
ZOREN	0,49	0,49	0,12	69,57	89,27	0,43	7,24	106,68	4,36	0,37	17,68	21,18	0,86	3,52

Table 4 : Financial Ratio Calculated for 2021

2021														
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
AKENR	0,96	0,95	0,43	70,50	87,96	0,39	14,25	393,02	5,41	-25,50	15,34	19,51	-64,58	- 349,10
AKSUE	0,49	0,47	0,34	75,84	84,25	0,22	6,58	18,57	1,24	-24,00	68,38	60,44	- 108,88	- 134,56
AYEN	0,62	0,62	0,21	62,40	67,48	0,35	9,57	0,00	1,17	2,51	36,03	41,56	7,09	9,16
ENJSA	0,90	0,87	0,03	34,20	70,16	1,09	7,17	72,18	3,70	8,15	27,11	17,58	7,47	27,66
NATEN	2,09	2,09	1,33	20,71	27,42	0,17	2,72	33,04	0,24	16,54	32,09	41,07	42,28	5,79
PAMEL	0,38	0,38	0,28	16,90	27,15	0,07	20,84	0,00	0,10	2,20	24,14	44,42	32,95	3,14
YAYLA	0,19	0,16	0,02	22,14	33,74	0,06	5,70	10,58	0,10	4,66	-4,49	-27,48	77,06	7,39
ZOREN	0,68	0,66	0,15	67,12	82,55	0,41	5,33	63,36	2,74	-0,30	16,01	18,51	-0,74	-1,97

Table 5: Financial Ratio Calculated for 2022

2022															
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K1
AKENR	1,11	1,10	0,39	51,77	74,63	0,96	12,78	10,63	652,9 1	4,67	-8,80	9	11,18	-9,21	-43,00
AKSUE	0,20	0,19	0,05	68,50	88,16	0,31	7,94	21,16	35,02	2,35	2,32	69,22	69,66	7,38	17,34
AYEN	1,46	1,46	0,91	40,51	55,17	0,89	19,04	16,42	0,00	2,22	20,96	37,86	39,55	23,46	56,03
ENJSA	0,70	0,65	0,27	32,26	63,55	1,87	14,86	12,76	68,29	5,46	32,03	18,74	10,26	17,17	93,77
NATEN	1,85	1,83	0,94	18,61	26,37	0,14	1,55	1,59	42,75	0,18	7,98	35,98	41,27	88,03	4,59
PAMEL	0,12	0,12	0,09	3,81	33,67	0,07	21,64	10,18	0,00	0,10	22,54	50,79	64,34	326,21	33,05
YAYLA	0,55	0,46	0,37	7,50	20,76	0,06	30,45	3,97	8,40	0,08	26,77	-22,55	-56,52	475,87	35,91
ZOREN	0,60	0,58	0,13	51,04	73,89	0,58	5,99	6,40	69,85	2,53	0,22	12,96	15,34	0,37	0,93

Fixing the Decision Matrix; Since the presence of a negative index value in the decision matrix causes problems in the calculation, the negative values in the relevant criteria columns of the decision matrix are turned into positive. Equations (7) are used for calculation purposes.

2. Normalization of the Adjusted Decision Matrix

The normalization process was carried out using Equation (2). The normalized decision matrices are shown in the figure below:

Table 6: Matrix with Normalization for 2020

2020														
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
AKENR	0,08	0,08	0,08	0,21	0,19	0,13	0,23	0,70	0,35	0,00	0,09	0,11	0,01	0,00
AKSUE	0,03	0,03	0,01	0,15	0,15	0,08	0,07	0,02	0,05	0,04	0,20	0,19	0,00	0,14
AYEN	0,05	0,05	0,03	0,16	0,14	0,08	0,13	0,00	0,05	0,11	0,13	0,15	0,03	0,16
ENJSA	0,11	0,11	0,02	0,09	0,13	0,38	0,07	0,12	0,21	0,18	0,12	0,10	0,05	0,03
NATEN	0,34	0,33	0,42	0,07	0,08	0,06	0,10	0,01	0,02	0,21	0,17	0,16	0,76	0,18
PAMEL	0,25	0,26	0,36	0,09	0,07	0,05	0,31	0,00	0,01	0,19	0,18	0,19	0,08	0,17
YAYLA	0,08	0,08	0,06	0,08	0,08	0,04	0,03	0,03	0,01	0,11	0,00	0,00	0,02	0,16
ZOREN	0,07	0,07	0,03	0,16	0,16	0,18	0,07	0,12	0,29	0,14	0,11	0,11	0,05	0,17

Table 7: Matrix with Normalization for 2021

2021														
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
AKENR	0,15	0,15	0,15	0,19	0,18	0,14	0,20	0,67	0,37	0,00	0,08	0,11	0,05	0,00
AKSUE	0,08	0,08	0,12	0,21	0,18	0,08	0,09	0,03	0,08	0,01	0,29	0,20	0,00	0,09
AYEN	0,10	0,10	0,08	0,17	0,14	0,13	0,13	0,00	0,08	0,15	0,16	0,16	0,13	0,15
ENJSA	0,14	0,14	0,01	0,09	0,15	0,39	0,10	0,12	0,25	0,18	0,13	0,10	0,13	0,16
NATEN	0,33	0,34	0,48	0,06	0,06	0,06	0,04	0,06	0,02	0,22	0,15	0,16	0,18	0,15
PAMEL	0,06	0,06	0,10	0,05	0,06	0,03	0,29	0,00	0,01	0,15	0,11	0,17	0,16	0,15
YAYLA	0,03	0,03	0,01	0,06	0,07	0,02	0,08	0,02	0,01	0,16	0,00	0,00	0,22	0,15
ZOREN	0,11	0,11	0,05	0,18	0,17	0,15	0,07	0,11	0,19	0,13	0,08	0,11	0,13	0,15

Table 8: Matrix with Normalization for 2022

2022															
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K1
AKENR	0,17	0,17	0,12	0,19	0,17	0,20	0,11	0,74	0,27	0,00	0,08	0,10	0,00	0,00	0,17
AKSUE	0,03	0,03	0,02	0,25	0,20	0,06	0,07	0,04	0,13	0,06	0,23	0,19	0,02	0,11	0,03
AYEN	0,22	0,23	0,29	0,15	0,13	0,18	0,17	0,00	0,13	0,17	0,15	0,15	0,03	0,18	0,22
ENJSA	0,11	0,10	0,09	0,12	0,15	0,38	0,13	0,08	0,31	0,23	0,11	0,10	0,03	0,25	0,11
NATEN	0,28	0,29	0,30	0,07	0,06	0,03	0,01	0,05	0,01	0,10	0,15	0,15	0,10	0,09	0,28
PAMEL	0,02	0,02	0,03	0,01	0,08	0,01	0,19	0,00	0,01	0,18	0,19	0,19	0,33	0,14	0,02
YAYLA	0,08	0,07	0,12	0,03	0,05	0,01	0,27	0,01	0,00	0,20	0,00	0,00	0,48	0,15	0,08
ZOREN	0,09	0,09	0,04	0,19	0,17	0,12	0,05	0,08	0,14	0,05	0,09	0,11	0,01	0,08	0,09

Step 3: Finding Entropy Values for Criteria

Entropy values will be calculated after the normalized decision matrix process. The k value, which is a logarithmic function, was calculated to obtain the entropy values. The value of k in the range $0 \leq ej \leq 1$ is a constant. To find the k value, the formula k = (ln(m))-1 was applied. Since there are 8 decision points during the ratio analysis, k = (ln(8))-1 = 0.48. Equation (3) is used for this.

Table 9 : Values Obtained by the Entropy Method of 2020

2020														
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
AKENR	-0,21	-0,21	-0,21	-0,33	-0,31	-0,27	-0,34	-0,25	-0,37	0,00	-0,21	-0,24	-0,03	0,00
AKSUE	-0,10	-0,09	-0,04	-0,29	-0,28	-0,21	-0,19	-0,08	-0,15	-0,14	-0,32	-0,32	0,00	-0,27
AYEN	-0,14	-0,15	-0,10	-0,29	-0,27	-0,20	-0,26	0,00	-0,14	-0,25	-0,27	-0,28	-0,11	-0,29
ENJSA	-0,25	-0,25	-0,08	-0,22	-0,27	-0,37	-0,18	-0,26	-0,33	-0,31	-0,26	-0,23	-0,15	-0,11
NATEN	-0,37	-0,37	-0,36	-0,19	-0,21	-0,17	-0,23	-0,03	-0,08	-0,33	-0,30	-0,29	-0,21	-0,31
PAMEL	-0,35	-0,35	-0,37	-0,21	-0,19	-0,15	-0,36	0,00	-0,06	-0,32	-0,31	-0,31	-0,21	-0,30
YAYLA	-0,20	-0,19	-0,16	-0,20	-0,20	-0,12	-0,11	-0,10	-0,05	-0,24	0,00	0,00	-0,07	-0,29
ZOREN	-0,18	-0,19	-0,10	-0,29	-0,30	-0,31	-0,18	-0,26	-0,36	-0,28	-0,24	-0,24	-0,14	-0,30

Table 10 : Values Obtained by the Entropy Method of 2021

2021														
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
AKENR	-0,29	-0,29	-0,29	-0,32	-0,31	-0,28	-0,32	-0,27	-0,37	0,00	-0,20	-0,24	-0,15	0,00
AKSUE	-0,20	-0,20	-0,26	-0,32	-0,31	-0,20	-0,22	-0,11	-0,21	-0,04	-0,36	-0,32	0,00	-0,22
AYEN	-0,23	-0,23	-0,19	-0,30	-0,28	-0,26	-0,27	0,00	-0,20	-0,28	-0,29	-0,29	-0,27	-0,29
ENJSA	-0,28	-0,28	-0,05	-0,22	-0,28	-0,37	-0,23	-0,26	-0,35	-0,31	-0,26	-0,23	-0,27	-0,29
NATEN	-0,37	-0,37	-0,35	-0,16	-0,16	-0,17	-0,12	-0,16	-0,07	-0,33	-0,28	-0,29	-0,31	-0,28
PAMEL	-0,17	-0,17	-0,23	-0,14	-0,16	-0,09	-0,36	0,00	-0,03	-0,28	-0,25	-0,30	-0,30	-0,28
YAYLA	-0,11	-0,09	-0,04	-0,17	-0,19	-0,08	-0,20	-0,07	-0,03	-0,29	0,00	0,00	-0,33	-0,29
ZOREN	-0,24	-0,24	-0,16	-0,31	-0,30	-0,28	-0,19	-0,24	-0,31	-0,27	-0,20	-0,24	-0,26	-0,28

Table 11 : Values Obtained by the Entropy Method of 2022

2022														
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14	K1
AKENR	0,17	0,17	0,12	0,19	0,17	0,20	0,11	0,74	0,27	0,00	0,08	0,10	0,00	0,00	0,17
AKSUE	0,03	0,03	0,02	0,25	0,20	0,06	0,07	0,04	0,13	0,06	0,23	0,19	0,02	0,11	0,03
AYEN	0,22	0,23	0,29	0,15	0,13	0,18	0,17	0,00	0,13	0,17	0,15	0,15	0,03	0,18	0,22
ENJSA	0,11	0,10	0,09	0,12	0,15	0,38	0,13	0,08	0,31	0,23	0,11	0,10	0,03	0,25	0,11
NATEN	0,28	0,29	0,30	0,07	0,06	0,03	0,01	0,05	0,01	0,10	0,15	0,15	0,10	0,09	0,28
PAMEL	0,02	0,02	0,03	0,01	0,08	0,01	0,19	0,00	0,01	0,18	0,19	0,19	0,33	0,14	0,02
YAYLA	0,08	0,07	0,12	0,03	0,05	0,01	0,27	0,01	0,00	0,20	0,00	0,00	0,48	0,15	0,08
ZOREN	0,09	0,09	0,04	0,19	0,17	0,12	0,05	0,08	0,14	0,05	0,09	0,11	0,01	0,08	0,09

Equation (4) was used to find entropy values for the criteria. The entropy values obtained are shown in the figure below:

Table 12: Ej Values Between 2020-2022

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
2020- e_j	-0,86	-0,86	-0,68	-0,97	-0,97	-0,86	-0,89	-0,47	-0,74	-0,90	-0,92	-0,92	-0,44	-0,90
2021- e_j	1,90	1,89	1,75	1,93	1,96	1,84	1,92	1,53	1,76	1,87	1,89	1,92	1,91	1,93
2022- e_j	-0,88	-0,87	-0,84	-0,89	-0,95	-0,79	-0,90	-0,45	-0,78	-0,88	-0,90	-0,92	-0,57	-0,90

5. Finding Degrees of Differentiation

The degrees of differentiation were found using Equation (5). The obtained degrees of differentiation are shown in the figure below

Table 13: D_J Values Between 2020-2022

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
2020- d_j	1,86	1,86	1,68	1,97	1,97	1,86	1,89	1,47	1,74	1,90	1,92	1,92	1,44	1,90
2021- d_j	1,90	1,89	1,75	1,93	1,96	1,84	1,92	1,53	1,76	1,87	1,89	1,92	1,91	1,93
2022- d_j	1,88	1,87	1,84	1,89	1,95	1,79	1,90	1,45	1,78	1,88	1,90	1,92	1,57	1,90

6. Calculation of Entropy Criterion Weights

The importance weights of the criteria were found using Equation (6). The resulting importance weights are shown in the figure below:

Table 14: Importance Weights of Criteria for 2020-2022

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
2020-wj	0,07	0,07	0,07	0,08	0,08	0,07	0,07	0,06	0,07	0,07	0,08	0,08	0,06	0,07
2021-wj	0,07	0,07	0,07	0,07	0,08	0,07	0,07	0,06	0,07	0,07	0,07	0,07	0,07	0,07
2022-wj	0,07	0,07	0,07	0,07	0,08	0,07	0,07	0,06	0,07	0,07	0,07	0,08	0,06	0,07

According to the results of the application carry out with the Entropy method, the most important financial performance criterion in 2020 is determined as the Financial Debt Ratio, Leverage Ratio, Gross Profit Margin, EBITBA Margin (0.08); Current Ratio , Cash Ratio , Acid-Test Ratio, Asset Turnover Ratio , Equity Turnover Receivables Turnover Ratio , Return On Assets, Return On Equity (0.07); Inventory Turnover Ratio , Net Profit Margin (0.6).

In 2021, the most important financial performance criterion is determined as the Leverage Ratio (0,08); Current Ratio , Cash Ratio , Acid-Test Ratio, Financial Debt Ratio, Asset Turnover Ratio ,Inventory Turnover , Receivables Turnover Ratio, Equity Turnover, Return On Assets, Gross Profit Margin , EBITBA Margin, Net Profit Margin **,** Return On Equity (0,07); Inventory Turnover Ratio (0,06).

In 2022, the most important financial performance criterion is determined as the Leverage Ratio, EBITBA Margin (0,08); Current Ratio , Cash Ratio , Acid-Test Ratio, Financial Debt Ratio , Asset Turnover Ratio , Receivables Turnover Ratio, Equity Turnover, Return On Assets , Gross Profit Margin, Return On Equity (0,07); Inventory Turnover Ratio, Net Profit Margin (0,06).

After weighting the importance levels of the financial performance ratios with the Entropy method, TOPSIS application is carried out in order to perform the performance analysis. Before the implementation phase, the characteristics of the criteria were determined. In this direction, Current Ratio, Acid-Test Ratio, Cash Ratio, Asset Turnover Ratio, Receivables Turnover Ratio, Inventory Turnover Ratio Equity Turnover, Return On Assets, Gross Profit Margin, EBITDA Margin, Net Profit Margin, Return On Equity are benefit criteria; Financial Debt Ratio, Leverage Ratio is considered as a cost criterion.

3.2. Topsıs Method

1. Creation of the Standard Decision Matrix

The ratio analysis data calculated in the study is applied using the TOPSIS method. At this stage, the normalization process of the decision matrix determined at the beginning of the analysis section is performed. The creation of the standard decision matrix was carried out using Equations (8) and (9). The standard decision matrices obtained as a result of applying the formula are shown in the figure below:

Table 15: Creation of the Standard Decision Matrix for 2020

2020														
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
AKENR	0,18	0,18	0,15	0,54	0,51	0,29	0,53	0,97	0,69	-0,70	0,08	0,14	-0,06	-0,77
AKSUE	0,06	0,06	0,01	0,41	0,40	0,18	0,16	0,03	0,10	-0,49	0,55	0,53	-0,06	-0,13
AYEN	0,10	0,11	0,05	0,42	0,37	0,17	0,29	0,00	0,09	-0,13	0,28	0,32	-0,02	-0,04
ENJSA	0,25	0,25	0,04	0,24	0,35	0,82	0,15	0,17	0,41	0,20	0,22	0,12	0,01	-0,62
NATEN	0,74	0,72	0,75	0,19	0,22	0,13	0,23	0,01	0,04	0,36	0,44	0,37	0,99	0,06
PAMEL	0,54	0,57	0,63	0,23	0,20	0,11	0,71	0,00	0,03	0,26	0,50	0,53	0,05	0,03
YAYLA	0,17	0,17	0,10	0,20	0,20	0,08	0,07	0,04	0,02	-0,15	-0,32	-0,37	-0,04	-0,02
ZOREN	0,15	0,15	0,05	0,42	0,44	0,39	0,15	0,17	0,58	0,02	0,15	0,16	0,00	0,01

Table 16: Creation of the Standard Decision Matrix for 2020

2021														
	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
AKENR	0,35	0,35	0,29	0,48	0,48	0,30	0,48	0,97	0,74	-0,64	0,16	0,19	-0,41	-0,93
AKSUE	0,18	0,17	0,23	0,52	0,46	0,17	0,22	0,05	0,17	-0,60	0,73	0,58	-0,69	-0,36
AYEN	0,23	0,23	0,14	0,43	0,37	0,27	0,32	0,00	0,16	0,06	0,38	0,40	0,04	0,02
ENJSA	0,33	0,32	0,02	0,23	0,38	0,83	0,24	0,18	0,51	0,20	0,29	0,17	0,05	0,07
NATEN	0,77	0,78	0,89	0,14	0,15	0,13	0,09	0,08	0,03	0,41	0,34	0,39	0,27	0,02
PAMEL	0,14	0,14	0,19	0,12	0,15	0,05	0,70	0,00	0,01	0,06	0,26	0,43	0,21	0,01
YAYLA	0,07	0,06	0,01	0,15	0,18	0,05	0,19	0,03	0,01	0,12	-0,05	-0,26	0,49	0,02
ZOREN	0,25	0,25	0,10	0,46	0,45	0,31	0,18	0,16	0,37	-0,01	0,17	0,18	0,00	-0,01

Table 17: Creation of the Standard Decision Matrix for 2020

2022														
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**	**K11**	**K12**	**K13**	**K14**
AKENR	0,39	0,40	0,27	0,45	0,44	0,40	0,27	0,99	0,56	-0,17	0,09	0,09	-0,02	-0,33
AKSUE	0,07	0,07	0,03	0,60	0,53	0,13	0,17	0,05	0,28	0,04	0,65	0,55	0,01	0,14
AYEN	0,52	0,53	0,63	0,35	0,33	0,37	0,40	0,00	0,27	0,39	0,36	0,31	0,04	0,44
ENJSA	0,25	0,23	0,19	0,28	0,38	0,79	0,31	0,10	0,66	0,60	0,18	0,08	0,03	0,73
NATEN	0,65	0,66	0,65	0,16	0,16	0,06	0,03	0,06	0,02	0,15	0,34	0,33	0,15	0,04
PAMEL	0,04	0,04	0,06	0,03	0,20	0,03	0,46	0,00	0,01	0,42	0,48	0,51	0,56	0,26
YAYLA	0,19	0,17	0,26	0,07	0,12	0,03	0,64	0,01	0,01	0,50	-0,21	-0,45	0,81	0,28
ZOREN	0,21	0,21	0,09	0,45	0,44	0,24	0,13	0,11	0,31	0,00	0,12	0,12	0,00	0,01

Step 2. Creating the Weighted Standard Decision Matrix

At this stage, each value in the standard decision matrix is multiplied by the criterion weights obtained by the Entropy Method, according to the column in which they were located, and the weighted standard decision matrix is obtained. The calculation is carried out using Equation (10). The weighted standard decision matrices are shown in the figure below:

Table 18: Weighted Matrix in 2020 Topsis Method

2020														
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**	**K11**	**K12**	**K13**	**K14**
AKENR	0,01	0,01	0,01	0,04	0,04	0,02	0,04	0,05	0,04	-0,05	0,01	0,01	0,00	-0,05
AKSUE	0,00	0,00	0,00	0,03	0,03	0,01	0,01	0,00	0,01	-0,03	0,04	0,04	0,00	-0,01
AYEN	0,01	0,01	0,00	0,03	0,03	0,01	0,02	0,00	0,01	-0,01	0,02	0,02	0,00	0,00
ENJSA	0,02	0,02	0,00	0,02	0,03	0,06	0,01	0,01	0,03	0,01	0,02	0,01	0,00	-0,04
NATEN	0,05	0,05	0,05	0,01	0,02	0,01	0,02	0,00	0,00	0,03	0,03	0,03	0,05	0,00
PAMEL	0,04	0,04	0,04	0,02	0,01	0,01	0,05	0,00	0,00	0,02	0,04	0,04	0,00	0,00
YAYLA	0,01	0,01	0,01	0,01	0,01	0,01	0,01	0,00	0,00	-0,01	-0,02	-0,03	0,00	0,00
ZOREN	0,01	0,01	0,00	0,03	0,03	0,03	0,01	0,01	0,04	0,00	0,01	0,01	0,00	0,00

Table 19: Weighted Matrix in 2021 Topsis Method

2021														
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**	**K11**	**K12**	**K13**	**K14**
AKENR	0,02	0,02	0,02	0,03	0,03	0,02	0,03	0,05	0,05	-0,04	0,01	0,01	-0,03	-0,06
AKSUE	0,01	0,01	0,01	0,04	0,03	0,01	0,02	0,00	0,01	-0,04	0,05	0,04	-0,05	-0,02
AYEN	0,02	0,02	0,01	0,03	0,03	0,02	0,02	0,00	0,01	0,00	0,03	0,03	0,00	0,00
ENJSA	0,02	0,02	0,00	0,02	0,03	0,05	0,02	0,01	0,03	0,01	0,02	0,01	0,00	0,01
NATEN	0,05	0,05	0,06	0,01	0,01	0,01	0,01	0,00	0,00	0,03	0,02	0,03	0,02	0,00
PAMEL	0,01	0,01	0,01	0,01	0,01	0,00	0,05	0,00	0,00	0,00	0,02	0,03	0,01	0,00
YAYLA	0,00	0,00	0,00	0,01	0,01	0,00	0,01	0,00	0,00	0,01	0,00	-0,02	0,03	0,00
ZOREN	0,02	0,02	0,01	0,03	0,03	0,02	0,01	0,01	0,02	0,00	0,01	0,01	0,00	0,00

Table 20: Weighted Matrix in 2022 Topsis Method

2022														
	K1	**K2**	**K3**	**K4**	**K5**	**K6**	**K7**	**K8**	**K9**	**K10**	**K11**	**K12**	**K13**	**K14**
AKENR	0,03	0,03	0,02	0,03	0,03	0,03	0,02	0,05	0,04	-0,01	0,01	0,01	0,00	-0,02
AKSUE	0,00	0,00	0,00	0,04	0,04	0,01	0,01	0,00	0,02	0,00	0,05	0,04	0,00	0,01
AYEN	0,04	0,04	0,04	0,02	0,02	0,02	0,03	0,00	0,02	0,03	0,02	0,02	0,00	0,03
ENJSA	0,02	0,02	0,01	0,02	0,03	0,05	0,02	0,01	0,04	0,04	0,01	0,01	0,00	0,05
NATEN	0,04	0,05	0,04	0,01	0,01	0,00	0,00	0,00	0,00	0,01	0,02	0,02	0,01	0,00
PAMEL	0,00	0,00	0,00	0,00	0,01	0,00	0,03	0,00	0,00	0,03	0,03	0,04	0,03	0,02
YAYLA	0,01	0,01	0,02	0,00	0,01	0,00	0,04	0,00	0,00	0,03	-0,01	-0,03	0,05	0,02
ZOREN	0,01	0,01	0,01	0,03	0,03	0,02	0,01	0,01	0,02	0,00	0,01	0,01	0,00	0,00

Step 3. Determination of Positive Ideal and Negative Ideal Solution Values

After the weighted standard decision matrix step, the positive and negative solutions required for TOPSIS should be obtained. At this stage in the study, the rates are divided into two categories: benefit and cost. If a high rate is positive for the company, it is called a benefit, or vice versa, if a high rate is negative, it is called a cost. 12 of the 14 ratios in the study were determined as benefits and 2 as costs. Positive and negative ideal solution values were found using Equations (11) and (12), respectively. The positive ($v+$) and negative ($v-$) ideal solutions obtained in this direction are shown in the figure below:

Table 21: Positive and Negative Ideal Solution Values

	K1	K2	K3	K4	K5	K6	K7	K8	K9	K10	K11	K12	K13	K14
2020-$v+$	0,05	0,05	0,05	0,01	0,01	0,06	0,05	0,05	0,04	0,03	0,04	0,04	0,05	0,00
2020-$v-$	0,00	0,00	0,00	0,04	0,04	0,01	0,01	0,00	0,00	-0,05	-0,02	-0,03	0,00	-0,05
2021-$v+$	0,05	0,05	0,06	0,01	0,01	0,05	0,05	0,05	0,05	0,03	0,05	0,04	0,03	0,01
2021-$v-$	0,00	0,00	0,00	0,04	0,03	0,00	0,01	0,00	0,00	-0,04	0,00	-0,02	-0,05	-0,06
2022-$v+$	0,04	0,05	0,04	0,00	0,01	0,05	0,04	0,05	0,04	0,04	0,05	0,04	0,05	0,05
2022-$v-$	0,00	0,00	0,00	0,04	0,04	0,00	0,00	0,00	0,00	-0,01	-0,01	-0,03	0,00	-0,02

Step 4. Calculating Distance to Positive and Negative Ideal Points

After calculating the S_i^+ and S_i^- values, the distance values of the TOPSIS method to the ideal points are calculated. While finding these values, the formula related to all the calculated financial ratios of the business in the study and the S_i^+ and S_i^- values found is applied. This formula is specified in Equations (13) and (14). Table 22 shows the Maximum Ideal Distance to Point values.

Table 22: Distance to the Maximum Ideal Point in the Topsis Method for the Years 2017-2021

	2020		2021		2022	
	S_i^+	S_i^-	S_i^+	S_i^-	S_i^+	S_i^-
AKENR	0,15	0,12	0,15	0,12	0,14	0,12
AKSUE	0,15	0,11	0,16	0,11	0,14	0,13
AYEN	0,14	0,11	0,12	0,12	0,09	0,13
ENJSA	0,12	0,17	0,11	0,15	0,11	0,12
NATEN	0,09	0,16	0,10	0,11	0,12	0,13
PAMEL	0,10	0,07	0,13	0,09	0,12	0,10
YAYLA	0,17	0,11	0,16	0,10	0,15	0,07
ZOREN	0,13	0,09	0,13	0,09	0,14	0,06

Step 5. Calculating Relative Closeness to the Ideal Solution

After the distance values to the maximum ideal point are found, the last stage of TOPSIS is started. In the last stage, the C_i* score value was calculated. The resulting value is between 0 and 1. If the C_i* score value is close to 1, it is shown that it is at the positive ideal point, and if it is close to 0, it is close to the negative ideal point. The success of the enterprises is shown by ordering the C_i * score values obtained from the largest to the smallest. The firm with the highest C_i* score becomes the best firm. This formula is specified in Equations (15). Table 23 shows the results of the C_i* score value and the ranking of the enterprises.

Table 23: $\boldsymbol{C_i}$* and Success Ranking in the Topsis Method for the Years 2020-2022

	2020		**2021**		**2022**	
	S_i^+	S_i^-	S_i^+	S_i^-	S_i^+	S_i^-
AKENR	0,15	0,12	0,15	0,12	0,14	0,12
AKSUE	0,15	0,11	0,16	0,11	0,14	0,13
AYEN	0,14	0,11	0,12	0,12	0,09	0,13
ENJSA	0,12	0,17	0,11	0,15	0,11	0,12
NATEN	0,09	0,16	0,10	0,11	0,12	0,13
PAMEL	0,10	0,07	0,13	0,09	0,12	0,10
YAYLA	0,17	0,11	0,16	0,10	0,15	0,07
ZOREN	0,13	0,09	0,13	0,09	0,14	0,06

According to the ranking results obtained by the TOPSIS method, the top three most successful enterprises for 2020 are NATEN ($\boldsymbol{C_i}$* =0.64), ENJSA ($\boldsymbol{C_i}$* =0.58) and AYEN ($\boldsymbol{C_i}$* =0.46); For 2021, ENJSA ($\boldsymbol{C_i}$* = 0.57), NATEN ($\boldsymbol{C_i}$* =0.53) and AYEN ($\boldsymbol{C_i}$* =0.51); For 2022, it has been determined as AYEN ($\boldsymbol{C_i}$* =0.58), ENJSA, NATEN ($\boldsymbol{C_i}$* =0.52) and AKSUE, AKENR ($\boldsymbol{C_i}$* =0.48). According to the application results, the most unsuccessful enterprises are YAYLA ($\boldsymbol{C_i}$* =0.39); For 2021, it was determined as YAYLA ($\boldsymbol{C_i}$* =0.38) and for 2022 it was determined as ZOREN ($\boldsymbol{C_i}$* =0.31).

Conclusion

Energy has been one of the most current issues in the world from the past to the present, and it is becoming more and more important. Many disasters that occur in the world, such as wars, global warming, and deterioration of the natural structure, are directly or indirectly based on the wrong consumption of energy resources. The gradual decrease in resources leads societies to new searches. For this reason, projects and cooperation between countries are organized to increase the use of renewable energy. The energy trade structures of the countries and their support for each other will be one of the issues that will be further emphasized by determining future targets. While making future-oriented decisions, companies consider the current situation and the past performances of the company and make analyses. As a result, they aim to maximize the value of the company with the decisions they make. One of the most important supporters of the current situation of the companies and the determination of their performance development in the past periods is financial analysis. With the data obtained as a result of financial analysis, companies determine the steps to be taken and company policies. As a result of the development of technology and industry, energy has an important place in human life. Energy consumption allows us to get an idea of the development level of countries. Especially in developing countries, energy consumption is increasing rapidly. The fact that energy production facilities require high-cost investments causes energy-dependent countries such as Turkey to import energy to meet their energy needs, incur high costs, and become one of the most important expense items.

However, since the need for energy increases very rapidly in countries that are dependent on foreign energy, the increase in the external debt of these countries is affected to a significant extent, and this situation has a serious negative impact on the economic structure of the countries. However, in order to be able to reach a strong position in the global competition that has emerged with the developments in the industry, it is necessary to produce industrial products while keeping costs low.

The aim of the study was in this direction, from the idea that the financial performances of companies could be measured with TOPSIS, and the application is carried out in this direction, and the relationship between them and stock returns is examined. The reason for choosing the TOPSIS method is its applicability. In the literature, studies have been carried out for different sectors using this method. In this context, the financial performances of the companies listed in BIST and operating in the renewable energy sector for the period of 2020–2022 were evaluated with the TOPSIS method, which is one of the multi-criteria decision-making methods, since it is the first period in which the maximum number of companies can be reached. While selecting the companies to be included in the application, companies that produce renewable energy equipment or companies that use non-renewable energy sources in energy production are not included in the evaluation. Most of the companies included in the application use non-renewable energy sources as well as renewable energy sources in energy production, since the production is realized using only renewable energy sources in 2020–2022, and the number of companies listed in the BIST is very few. The results to be achieved will reflect the total performance of the company.

Ratio analysis is used to measure their financial performance. First, the results of the ratio analysis were evaluated within themselves. Afterwards, the ratio values reached were defined as criteria, and their weights among performance indicators are determined by the Entropy method. In order to have information about the performance of the enterprise with a single value and to be able to make an evaluation at once for all companies in the sector with this single value reached, the TOPSIS method is applied. When the asset structure of companies with renewable energy sources among their production activities is examined, it is seen that fixed assets are predominantly fixed. From the point of view of the sector, electricity, etc., energy production realizations, it can be interpreted that the investments made are long-term. In addition, the equipment used by companies in the renewable energy sector seems logical considering their land investments.

In this context; in the comparison of liquidity ratios for 2020, NATEN has the highest liquidity ratio and AKSUE has the lowest. The low liquidity ratio indicates that there may be difficulties in paying the debts. In 2021, NATEN has again be the company with the highest liquidity ratio. The company with the lowest liquidity was YAYLA . For 2022, while NATEN has the best ratio, AKSUE has the lowest liquidity ratio. The rate of NATEN company is much higher than the sector average, and it has been interpreted that there may be idle funds because the money cannot be used well. When the activity analysis rates are examined, it is expected that the turnover rate of the companies that consume their stocks quickly is also high. In this situation, for AKENR, ENJSA, and ZOREN, it can be said that the stock turnover rate is high. However, since some of these companies use renewable energy sources and some of them use both renewable and non-renewable energy sources, their stock ratios may have a misleading result. When an analysis is carried out according to the fields of activity, it is seen that companies using hydroelectric, wind, and solar energy generally have rapid turnover in terms of their stocks. In connection with the speed, the number of days left in stock also decreases as the speed increases. According to the analysis of the financial structure ratios, it is concluded that AKENR company is in a risky situation for the years 2020, 2021, and 2022 due to its high leverage ratio and negative equity. In the event of the liquidation of the business, there is a risk of not being able to collect their receivables for the lenders. The firm with the lowest level of financial leverage and below the industry average is PAMEL. This indicates that the company is safe. When the profitability ratios are examined, it is evaluated that the averages of the renewable energy sector are not at high levels. In the comparison between companies, it seems that the ratio of NATEN between the years 2020-2022 is in a profitable position, mostly because it is above the sector average. When the structure of the energy sector is examined, it is seen that enterprises use financial debt more than equity. Although this situation is positive in terms of resource costs, it is a negative indicator in terms of the risk incurred. When examined in this context, it can be concluded that financial debt and financial debt elements are important indicators in the analysis of enterprises as an effect of the sector structure. Long-term investments—in other words, the return on investments made in fixed assets—may be longer than expected, and therefore companies may have to bear additional costs. In addition to long-term investment decisions, it is important to manage current assets efficiently. A sufficient level of net working capital should be kept in case of a negative situation. In future studies, it is recommended to make an evaluation on a different and broader scale of financial criteria. The decision-making model created in this study can be applied to decision problems such as site selection, product selection, and different performance evaluations in future studies.

In practice, all of the financial ratios calculated from the annual data for 2020 were defined as criteria, and they are weighted using the Entropy method in order to determine their weights objectively. After this stage, performance indicators are ranked by being reduced to a single score with TOPSIS, one of the multi-criteria decision-making methods. These ratios, which are determined according to the weighting achieved in the first application, can also be described as the main indicators of financial performance. According to TOPSIS results, the top three most successful enterprises for 2020 are NATEN, ENJSA, and AYEN; for 2021, ENJSA, NATEN, and AYEN; and for 2022, it has been determined as AYEN, ENJSA, NATEN, AKSUE, and AKENR. According to the application results, the most unsuccessful enterprises are YAYLA for 2020 and ZOREN for 2022. Turkey is very rich in renewable energy sources, especially wind and solar. Investments in these resources are increasing, but they are insufficient compared to the investments of other countries. Our country is largely foreign-dependent in the energy sector, and the increasing level of indebtedness in foreign currency also negatively affects the profitability of the company in the sector. This situation causes an increase in input costs and inflationary pressure on a macroscale in production companies where energy is a source. Renewable energy sources should be supported by investments, and an industry approach based on fossil fuel consumption should be abandoned. In addition, making investments in this direction will reduce foreign dependency and alleviate the current debt burden. In future studies, it is recommended to make an evaluation on a different and broader scale of financial criteria. The decision-making model created in this study can be applied to decision problems such as site selection, product selection, and different performance evaluations in future studies.

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