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A Special Look into the Mining Companies in Borsa Istanbul with MCDA Methods

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Abstract

Organizational performance is crucial in determining the position of a company within its industry. Especially with financial performance, the positive and negative aspects of a firm can be determined with comparisons to similar companies, in an effective and practical fashion. In financial performance analyses where multiple criteria need to be scrutinized, multi-criteria decision analyses (MCDA) have used extensively in recent years. Due to its geological infrastructure, the mining sector has a strategic importance in Türkiye. To that end, mining companies traded in Borsa Istanbul were examined in this study in terms of financial performance and all 5 companies operating in the aforementioned sector were ranked according to their performance scores. 6 accounting and valuation-based criteria were used along with standard deviation weighting technique, and 7 quarterly periods between 2021 and 2022 were investigated in this research. Interestingly, Gray Relational Analysis (GRA) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS) methods generated similar results when overall industry is analyzed, in terms of performance scores. Thus, GRA and TOPSIS methods are suggested to financial decision makers as a decision support system in order for them to take strategical decisions in capital markets where uncertainty is severely experienced.

Keywords: Capital Markets, Financial Performance, MCDA

Introduction

The financial performance of companies in their respected sectors affect many financial stakeholders and attract the attention of banks, investors, competitors and academics. The partners are curious about the benchmarking scores of the company within its industry, in order to determine how effectively the firm can achieve its founding goals. Creditors place emphasis on industry performance in order to determine the eligibility of companies for lending. Existing and potential investors, on the other hand, are in a race to get the right stocks from different sectors on their radar while diversifying their portfolios. To that end, a complex ranking problem involving many different criteria needs to be solved with the most appropriate approach.

Problems that need to be solved in the presence of multiple criteria and alternatives are classified in the study area of multi-criteria decision analysis (MCDA). All companies in a given sector can be

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analyzed with these methods using various financial ratios, and ultimately firms can be ranked from most to least successful according to their final scores, for the analyzed period. Operations research is concerned with designing mathematical background for the subjective evaluation of performance criteria (Behzadian et al., 2012). MCDA applications often preferred in solving real-world problems such as strategy management (Fouladgar et al., 2012), risk management (Ganguly & Guin, 2013), and economic valuation (Balezentis et al., 2012) that surely involve uncertainty.

Since Türkiye has a complex geology and is located in a rich geography between Europe and Asia, it has different mineral deposits. About two-thirds of the mineral products hoisted in the world can be extracted in Türkiye. In addition, Türkiye ranks 28th in terms of production value and 10th in terms of mineral diversity among 132 countries globally that can extract minerals.

In this study, the financial performance of all companies operating in the Turkish mining sector and traded in Borsa Istanbul were analyzed. This analysis was made with Gray Relational Analysis (GRA) and Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), which are among the most popular and practical MCDA methods, especially preferred in the scenarios involving uncertainty. In the study, which analyzed 7 quarterly periods with 6 accounting and valuation-based criteria determined, companies operating in the mining sector were ranked according to their success, in terms of financial performance.

The general outline of this study can be summarized as follows: In the second section of the study, financial performance analysis with MCDA methods in the literature are demonstrated. In the third section, the weighting technique and methods used in the study are clarified. According to the final results generated by each method in the fourth section, the financial performance rankings for companies were determined. In the fifth and last section, the overall results of this study are summarized and the nature of future research is scrutinized.

Literature Review

In recent years, financial performance analyzes have moved out of the axis of evaluations based on statistics and econometrics, and calculations have gained momentum through artificial intelligence, machine learning, big data mining and operations research (Ho & Wu, 2009). For this purpose, financial metrics are used in performance calculations. Financial ratios can be classified in two categories according to their context, which are accounting-based and valuation-based. Among these ratios, accounting-based ratios capture historical information flow, while valuation-based ratios shed light on the future of companies (Sandoval, 2001).

MCDA methods are preferred when a complex problem with uncertainty needs to be solved. Determining the optimum among the alternatives and making a general ranking are among the most pivotal goals of MCDA methods (Yang et al., 2007). These methods are also used in the analysis of many real-life complex scenarios, especially in capital markets where uncertainty is intensely felt (Tan et al., 2012; Lu et al., 2013). Modern competitive environments with intense competition have directed financial stakeholders to prefer decision-making tools that can process larger data sets instead of traditional methods (Fethi & Pasiouras, 2010; Zacharia et al., 2011). Indeed, the purpose of

financial performance analyzes is to rank companies in order to trace the divergences between most successfull and least successfull performers (Yang et al., 2007).

In a study examining the financial performance of aviation companies in the literature, GRA and TOPSIS methods were used together (Feng & Wang, 2000). The financial performance of computer manufacturers traded on the Taiwan Stock Exchange was analyzed in another research, and the TOPSIS method was preferred for the purpose of performance ranking (Wang & Hsu, 2004). In another research examining the financial performance of container companies operating in Taiwan, the TOPSIS method was yet again favored (Wang, 2008). The financial performance of container shipping companies was investigated in another study, and the GRA method was used for performance ranking (Wang & Lee, 2010). In another research, the cement companies traded in Borsa Istanbul were examined through TOPSIS method (Ertuğrul & Karakaşoğlu, 2009).

The financial performance of banks operating in Turkey was analyzed with FAHP and TOPSIS methods in a study (Seçme et al., 2009). In another research, TOPSIS method was used to measure the financial performance of airline companies and to rank them according to their performance (Kung et al., 2011). The financial performance of maritime companies was evaluated in another study via GRA method (Lee et al., 2012). TOPSIS is one of the MCDA methods used in a study that analyzes the financial performance of companies traded in Borsa Istanbul and operating in the manufacturing sector (Yalçın et al., 2012). Another research examined the financial performance of accommodation companies operating in Borsa Istanbul and analyzes were carried out using the TOPSIS method (Yılmaz & Konyar, 2013).

Methodology

In order to rank the alternatives correctly, first of all, the right criteria must be determined. In financial performance analysis, certain financial ratios are used to perform the ranking process. With these ratios, obtained from the financial statements of the enterprises, the functioning and failing aspects of the companies can be determined (Drake & Fabozzi, 2010). When recent literature is scrutinized, it is seen that the studies on financial performance analysis focus on different parameters, but also use some ratios frequently (Gallizo & Salvador, 2003; Prasad & Ravinder, 2011). The first ratio frequently seen in financial performance analyzes is the return on assets (ROA). This metric, which is one of the oldest and popular among financial ratios, shows how effectively a company uses its assets (Palepu et al., 2000). The market-to-book (M-to-B) ratio is an important parameter that demonstrates how much the company has developed in terms of market value compared to the capital invested by the partners (Bağcı & Yerdelen Kaygın, 2018). Net profit growth (NPG) is also used in performance studies as one of the profitability ratios that signifies the extent to which the company is progressing on a route that will satisfy the shareholders in terms of sustainable revenues (Moghimi & Anvari, 2014).

Earnings per share (EPS) is a critical performance criterion that expresses how much return the company is making from a shareholder perspective. It is considered a pivot financial ratio, as it shows the earnings expectations of the shareholders and gives an overall idea about the future of the company (Jordan et al., 2007). Market value added (MVA), which is more modern compared to other

accounting-based ratios, focuses on the extent to which investor-provided capital is increased. Since this increase is also associated with the market value, it is regarded as a ratio that demonstrates the efficiency of the company management (Gapenski, 1996). As a capital budgeting application, another performance indicator that displays the extent to which loan is used, compared to capital is the debt ratio. This ratio is used in financial performance analyzes in order to observe how efficiently companies use their debts (Bulgurcu, 2012).

Gray Relational Analysis (GRA)

GRA is one of the MCDA methods based on correlation. The most important advantages of this method are that it does not need a large number of data, produces results compatible with qualitative analysis, does not contain typical probability distribution, is simple to understand and practical for decision-makers (Madhuri & Chandulal, 2010). This method is used in the fields of engineering, business and finance (Wuvei, 2011; Chen, 2012; Hsu, 2014). The steps of GRA are summarized below.

Stage 1: The objective values of Pareto-optimal solutions are normalized by:

$$F_{ij} = \frac{f_{ij} - min_{i\in m} f_{ij}}{max_{i\in m} f_{ij} - min_{i\in m} f_{ij}} \quad (1)$$

$$F_{ij} = \frac{max_{i\in m} f_{ij} - f_{ij}}{max_{i\in m} f_{ij} - min_{i\in m} f_{ij}} \quad (2)$$

Stage 2: The reference network points are computed by:

$$F_j^+ = max_{i\in m} F_{ij} \quad (3)$$

Stage 3: The difference between F_j^+ and F_{ij} is calculated by:

$$\Delta I_{ij} = |F_j^+ - F_{ij}| \quad (4)$$

Stage 4: The value of GRC of each optimal solution is found by:

$$GRC_i = \frac{1}{m} \sum_{j=1}^{n} \frac{\Delta min + \Delta max}{\Delta I_{ij} + \Delta max} \quad (5)$$

Stage 5: Ultimately the largest GRC_i is determined

Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS)

The TOPSIS method ranks the alternatives according to their proximity and distance to the positive and negative ideal solutions. The closest to the positive ideal solution and the farthest from the negative ideal solution is regarded as the most successfull alternative (Olson, 2004). TOPSIS method was used in a study in which the financial performance of tourism companies traded in Borsa Istanbul were analyzed (Türegün, 2022). In another study where companies' social responsibility degrees were evaluated, the TOPSIS method was preferred (Lamata et al., 2018). Apart from this, the stages of the method applied in studies, such as banking performance valuation (Rus, 2018), credit risk valuation (Shen et al., 2018), are summarized below.

Stage 1: The normalized decision matrix is created with the following equation:

$$F_{ij} = \frac{f_{ij}}{\sqrt{\sum_{i=1}^{m} f_{ij}^2}}$$

(6)

Stage 2: The weighted normalized matrix is obtained with the following formula:

$$v_{ij} = F_{ij} \times w_j$$

(7)

Stage 3: The positive (A^+) and negative (A^-) ideal solutions are computed with the following formulas:

$$A^+ = \{(Max_i(v_{ij}) \,|\, j \in J), (Min_i(v_{ij}) \,|\, j \in J') \,|\, i \in 1, 2, \dots, m\} = \{v_1^+, \dots, v_j^+, \dots, v_n^+\}$$

(8)

$$A^- = \{(Min_i(v_{ij}) \,|\, j \in J), (Max_i(v_{ij}) \,|\, j \in J') \,|\, i \in 1, 2, \dots, m\} = \{v_1^-, \dots, v_j^-, \dots, v_n^-\}$$

(9)

Stage 4: The distance values of the aforementioned ideal solutions are computed with the following equations:

$$S_{i+} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^+)^2} \qquad i = 1, 2, 3, \dots, m$$

(10)

$$S_{i-} = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2} \qquad i = 1, 2, 3, \dots, m$$

(11)

Stage 5: Finally, the relative proximity to ideal solution is calculated with the following equation:

$$C_i = \frac{S_{i-}}{S_{i-} + S_{i+}}$$

(12)

Standard Deviation Weighting Technique

The technique that determines the weights of objectives according to their standard deviations is called the Standard Deviation weighting technique. It is used as an alternative objective weighting technique in MCDA studies (Xu & Da, 2010). The steps of the technique are summarized below.

Stage 1: The objective matrix is normalized with the following equations based on the type of the objectives:

$$F_{ij} = \frac{f_{ij} - min_{i \in m} f_{ij}}{max_{i \in m} f_{ij} - min_{i \in m} f_{ij}} \qquad for\ benefit\ objective$$

(13)

$$F_{ij} = \frac{max_{i \in m} f_{ij} - f_{ij}}{max_{i \in m} f_{ij} - min_{i \in m} f_{ij}} \qquad for\ cost\ objective$$

(14)

Stage 2: The standard deviation values of each objective is calculated with the following formula:

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{m} (F_{ij} - \overline{F_j})^2}{m}} \qquad j \in \{1,2,\dots,n\}$$

(15)

Stage 3: The weight for each objective is determined by:

$$w_j = \frac{\sigma_j}{\sum_{k=1}^{n} \sigma_k} \quad j \in \{1,2,\dots,n\}$$

(16)

Findings and Results

In this study, financial performance analysis of 5 companies operating in the mining sector and traded in Borsa Istanbul was performed. GRA and TOPSIS methods were used in the study, which examines 7 quarters over 6 criteria based on accounting and valuation. The decision matrices used for each period and integrated into GRA and TOPSIS methods are given in Table 1 below.

Table 1. Decision matrices for all analyzed periods

	ROA	EPS	M-to-B	Debt	NPG	MVA	
ALMAD	-0.83472	-0.83848	-0.04293	-0.18407	-1.14526	0.015116	
IPEKE	-0.6192	-0.58013	-0.19674	0.073873	-21.797	-0.26943	
KOZAL	-0.66735	-0.63435	0.131964	0.113815	26.90781	0.381674	2021/I
KOZAA	-0.62045	-0.58157	-0.178	0.096598	-22.0088	-0.38481	
PRKME	-0.25296	-0.20094	-0.08885	0.025625	-0.88663	-0.73066	
ALMAD	-2.59502	-2.18397	-0.39021	-0.5452	1.863635	-0.4472	
IPEKE	0.893186	1.066925	-0.0987	-0.00863	-0.16376	-0.12143	
KOZAL	0.871816	1.031657	-0.09141	0.020304	-0.18157	-0.09799	2021/II
KOZAA	0.894023	1.067492	-0.07585	0.01053	-0.16561	-0.2032	
PRKME	0.346715	0.387666	-0.11742	0.055367	-0.21651	-3.62841	

ALMAD	-0.8977	-0.90296	-0.3523	-0.45807	-0.30664	-0.61114	
IPEKE	0.271835	0.327612	-0.07283	-0.07833	-0.45096	-0.13624	
KOZAL	0.323084	0.388143	-0.23	-0.08611	-0.47902	-0.42679	2021/III
KOZAA	0.271922	0.327494	-0.01513	-0.0695	-0.45148	-0.02639	
PRKME	0.159092	0.172903	-0.07302	-0.02591	-0.93159	0.788845	
ALMAD	-24.8869	-28.0799	-0.10287	-0.70635	-1.30973	1.246285	
IPEKE	0.318195	0.492326	0.073244	0.300834	0.712974	0.317263	
KOZAL	0.394727	0.609072	0.081349	0.294597	1.272626	0.379046	2021/IV
KOZAA	0.319226	0.493528	0.149616	0.314109	0.714458	0.857285	
PRKME	1.609506	2.298842	0.135673	0.279806	38.6241	-0.68729	
ALMAD	-0.06469	0.128681	-0.0006	0.44998	24.93044	0.167638	
IPEKE	-0.68653	-0.66159	0.124052	-0.0879	-0.46368	0.441119	
KOZAL	-0.67577	-0.6478	0.12662	-0.09401	-0.09263	0.44642	2022/I
KOZAA	-0.68647	-0.6617	0.326161	-0.07846	-0.45922	1.223193	
PRKME	-0.80653	-0.79936	-0.03534	-0.117	-0.97652	0.964966	
ALMAD	0.086438	0.209553	0.733117	0.676963	0.268235	3.650355	
IPEKE	0.581624	0.660354	-0.05072	-0.03971	-0.70655	-0.06211	
KOZAL	0.603474	0.691651	0.011896	-0.05862	-0.44709	0.089213	2022/II
KOZAA	0.581902	0.660522	-0.04595	-0.03396	-0.70581	-0.05381	
PRKME	3.138009	4.071562	-0.19914	0.158376	37.01548	3.23687	
ALMAD	0.69949	0.902299	0.782571	-0.15645	16.81399	1.790332	
IPEKE	0.776593	0.77298	0.904307	0.002579	3.298469	2.436618	
KOZAL	0.897584	0.737807	1.313383	0.266808	1.013423	2.351375	2022/III
KOZAA	0.777531	0.773624	0.582668	0.01797	3.289813	1.501885	
PRKME	0.205041	0.286496	1.208167	0.044889	0.129822	-3.63091	

According to the standard deviation weighting technique, the weights for 6 criteria were calculated and determined. The weights computed, using the equations (13) through (16), are shown in Table 2. Although the weight of criteria differentiates among periods, it is seen that NPG and MVA have higher weights when compared to other metrics. In this sense, it can be said that these rates are more crucial for the mining industry in the time frame examined.

Table 2. Weights calculated for each period according to the Standard Deviation Weighting Technique

	ROA	EPS	M-to-B	Debt	NPG	MVA
2021/I	0.15725	0.155587	0.172511	0.175579	0.176672	0.162401
2021/II	0.168051	0.167168	0.163141	0.163428	0.170273	0.167938
2021/III	0.174688	0.173435	0.169299	0.168406	0.156088	0.158083
2021/IV	0.172361	0.171065	0.159398	0.17569	0.171431	0.150054
2022/I	0.161118	0.162489	0.158914	0.174117	0.177781	0.165581
2022/II	0.154232	0.158884	0.152793	0.164468	0.171753	0.19787

2022/III	0.164294	0.161874	0.173781	0.15081	0.171706	0.177535

In compliance with the decision matrices and calculated weights, the final GRA method results generated for each period are given in Table 3 below. Accordingly, while the IPEKE company has never been the first company, KOZAA has been the first performer for 3 quarters. In the calculation in which the 7-period performance is evaluated as a whole, PRKME company took the first place overall, while ALMAD company took the second place. In general, the company with the least performance was determined to be IPEKE.

Table 3. Final results for each period according to the GRA method

	2021/03K	2021/06K	2021/09K	2021/12K	2022/03K	2022/06K	2022/09K	All
ALMAD	0.673398	0.734998	0.666667	0.666667	0.754207	0.667757	*0.876758*	0.719265
IPEKE	0.568084	0.826632	0.785935	0.726149	0.626014	0.598887	0.766361	0.533461
KOZAL	*0.779886*	0.825816	0.744542	0.733755	0.630483	0.609251	0.798156	0.642617
KOZAA	0.560102	*0.832774*	*0.814217*	0.790498	*0.754244*	0.598012	0.717734	0.555387
PRKME	0.720453	0.679114	0.765358	*0.826036*	0.633908	*0.861998*	0.591964	*0.774949*

The TOPSIS final results for all analyzed periods are given in Table 4 below. While PRKME company secured the first place in 3 periods, all other companies were able to be first in only one quarter. In the general calculation, which evaluates 7 quarters as a single period, ALMAD company took the first place by a small margin, and PRKME took the second position. Again, the lowest performing company in general was observed as IPEKE.

Table 4. Final results for each period according to the TOPSIS method

	2021/03K	2021/06K	2021/09K	2021/12K	2022/03K	2022/06K	2022/09K	All
ALMAD	0.586634	0.501224	0.311863	0.42086	0.46341	0.43108	*0.865143*	*0.524164*
IPEKE	0.206199	*0.579229*	0.618648	0.510595	0.458107	0.344895	0.61267	0.160031
KOZAL	*0.605496*	0.571789	0.560114	0.519076	0.465007	0.361312	0.460127	0.347288
KOZAA	0.164994	0.576056	0.639867	0.554211	*0.552259*	0.343813	0.563705	0.180899
PRKME	0.35012	0.440532	*0.654438*	*0.581021*	0.43831	*0.624756*	0.288842	0.48445

When the outputs of the methods were compared, it was observed that the final results were sound and consistent. In cases where there is uncertainty and shortage of information, GRA is one of the most prominent methods exercised (Adeyemi-Kayode et al., 2022). TOPSIS has also been used for performance evaluation in the development of cleaner production and sustainability in iron and silver industries (Wang et al., 2020). The TOPSIS and GRA methods used in this study have been preferred not only in financial performance studies mentioned in the literature section, but also in ecological assessments of mineral-rich cities (Zhang et al., 2021).

The results obtained in this study are consistent with the results found in previous studies on financial performance (Wu et al., 2010; Huang & Peng, 2012; Suvvari & Goyari, 2019). Consequently, GRA and TOPSIS methods are recommended to financial decision makers.

Conclusion and Discussion

Organizational performance is a parameter that shows the extent to which companies have achieved their previously determined goals. The most vital element of organizational performance is financial performance. Having a pivotal role for all financial stakeholders, financial performance analyzes require detailed analysis of multiple elements. In capital markets where uncertainty is intense, MCDA methods function as a decision support system in accelerating objective decision-making processes by minimizing subjectivity. Thus, it is possible for decision makers to solve complex problems related to real life with minimum cost. In this study, financial performance analyzes of all companies traded in Borsa Istanbul and operating in the mining sector were made using GRA and TOPSIS methods, and companies were ranked according to their success for each period.

In the comparative analysis conducted in this study, the standard deviation weighting technique, one of the objective weighting techniques, was preferred. The calculations revealed that NPG and MVA ratios are determinant for the analyzed mining sector. In addition, in the analyses conducted separately for TOPSIS and GRA methods, only the first and second ranked companies changed with a small margin for the two aforementioned methods, while the companies in the third, fourth and fifth places were found to be the same.

As demonstrated in this study, GRA and TOPSIS methods can be used to make effective strategic management and portfolio diversification decisions. In future studies, in order to gain a wider perspective, the mining industry can be analyzed through different MCDA methods and the relationship between the results of these methods can be examined comparatively. In addition, the mining sector in developed and emerging markets can be analyzed comparatively with different MCDA methods and the results produced by these methods can be interpreted over a larger data set in order to have a broader perspective on various capital markets.

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