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**Araştırma Makalesi**

# Evaluation the Performances of Portfolios Created with TOPSIS and Grey Relational Analysis Methods during Covid-19 Pandemic

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**Abstract**
In this study, portfolio diversification was tried to be made based on stock market performance ratios with TOPSIS and Grey Relational Analysis (GRA) methods using quarterly data of companies operating in Borsa Istanbul Banks (XBANK), Wholesale & Retail Trade (XTCRT) and Textile & Leather (XTEKS) between 2015-2019. In the next stage, the performances of the created portfolios during the pandemic period were tried to be determined by comparing various indicators. As result, it was seen that the portfolio formed by the companies with the lowest performance in terms of stock market performance ratios reflects the highest average percentage change in positive sense. It has been determined that the return of the created portfolios is higher than the yield of BIST100 (XU100), BIST Banks XBANK, Gram Gold and US Dollar alternatives. This situation can be interpreted as TOPSIS, and GRA methods can be used as an alternative method in creating profitable portfolios.

**Keywords:** Financial Performance, Stock Market Performance Ratios, TOPSIS, Grey Relational Analysis.
**JEL Classification Codes**: G11, M21

**Topsis ve Gri İlişkisel Analiz Yöntemleri ile Oluşturulan Portföylerin Performanslarinin Pandemi Sürecinde Değerlendirilmesi**

**Öz**
Bu çalışmada Borsa İstanbul bankacılık, perakenden ve toptan ticaret ve tekstil olmak üzere üç farklı sektörde faaliyet gösteren şirketlerin 2015-2019 dönemi çeyrek dönemlik verilerinden yararlanılarak TOPSİS ve Gri İlişkisel Analiz yöntemleri ile borsa performansı oranları temelinde portföy çeşitlendirmesi yapılmaya çalışılmıştır. Sonraki aşamada, oluşturulan portföylerin pandemi dönemindeki performansları çeşitli göstergelerle karşılaştırmalı olarak tespit edilmeye çalışılmıştır. Sonuç olarak borsa performansı oranları bağlamında en düşük performansa sahip şirketlerin oluşturdukları portföyün pozitif anlamda en yüksek ortalama yüzdesel değişimi yansıttığı görülmüştür. Oluşturulan portföylerin getirisinin BIST100, BIST Bankacılık, Gram Altın ve Dolar alternatiflerinin getirisinden yüksek çıktığı tespit edilmiştir. Bu durum TOPSIS ve Gri ilişkisel analiz yöntemlerinin karlı portföylerin oluşturulmasında alternatif bir yöntem olarak kullanılabilecekleri şeklinde yorumlanabilir.

**Anahtar Kelimeler:** Finansal Performans, Borsa Performansı Oranları, TOPSIS, Gri İlişkisel Analiz
**JEL Sınıflandırma Kodları**: G11, M21

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## 1. Introduction

Financial markets are one of the critical factors in economic development in all developed and developing countries. Financial markets direct financial resources to help countries achieve their economic goals. One of the essential elements of financial markets is stock markets. Today, with the globalizing world, financial markets and stock markets have become global markets. While the competitive environment is increasing, investors have sought different and more effective methods to gain profit. For this purpose, besides fundamentally technical analysis methods, multi-criteria decision-making methods, especially in recent years, attract attention as frequently recommended methods in the academic field while evaluating companies' performance. Determining company performances, which is vital for managers, lenders and various state organizations and investors is critical to put forward policies that are more effective in the next process and increase companies' stability by gaining better performance and competitive advantage.

Investors make their investment decisions by considering many investment alternatives and several criteria that are likely to affect investment decisions. In this context, investors try to determine the most profitable investment tools to increase their portfolios' profitability and income. Evaluating stocks and stocks' performances in stock investments and determining the stocks to be invested represent a stressful and challenging process for investors. Modelling problems with economic dimensions is incredibly complicated for individuals. The evaluation of a company's financial performance is seen as interesting by different society segments, such as managers, creditors, financial analysts, portfolio managers, scientists, and investors.

An investor can benefit from technical and fundamental analysis methods while deciding to buy and sell stocks. Technical analysis is about analyzing data such as historical price/earnings and the stock's trading volume. Fundamental analysis consists of qualitative and quantitative analysis of the company's activity structure, activity results and activity expectations. An investor who conducts a fundamental analysis begins the analysis process to examine the country's general economic conditions and conjunctural structure. This is followed by sector analysis and firm analysis (Özen, Yeşildağ and Soba, 2015) Investors aim to increase their income and wealth with the savings they have. Stocks are one of the financial investments that will serve this purpose. In order to obtain the desired returns, the best decision should be made by analyzing the stocks well. While making this decision, investors have to consider different indicators that are specific to the company or not. One of the firm-specific indicators is financial ratios. Financial ratios are useful indicators of a firm's performance and financial condition. Financial ratios can be classified according to the information they provide. Investors can also make their investment profits based on financial ratios.

Financial ratios calculated based on companies' financial reports in specific periods are generally grouped under the titles of liquidity, activity, debt, profitability, and stock market performance. Stock market performance ratios also refer to the ratios considered in technical analysis or revealed by technical analysis. Stock market performance ratios represent ratios that investors more consider in equity investments. Stock market performance ratios representing rates such as Price / Earnings, Market Value / Book Value, Dividend Yield, and earnings per share (EPS) help make future decisions based on stocks' performances for their previous periods.

Multivariate decision methods widely used in the literature are recommended to solve investors' problem in making decisions by using a large number of variables. Multi-criteria decision-making (MCDM) methods, examples of which we have encountered frequently in recent years, enable individuals to facilitate their financial decision-making processes and reach the most accurate decision in the shortest and least demanding way. MCDM systematizes the decision-making process and ensures consistent systematic results. Quantitative methods such as Analytical Hierarchy Process (AHP), PROMETHEE, COPRAS, ELECTRE, Gray Relational Analysis, Economic Value Added (EVA), Market Value Added (MVA), Data Envelopment Analysis (DEA), Malmquist Total Factor Efficiency Index (TFV) and TOPSIS are used in many different areas for decision-making.

In this study, using the data of companies operating in three different sectors between 2015 and 2019, it was tried to diversify the portfolio over companies determined based on stock market performance ratios with TOPSIS and GRA methods. The portfolios formed as a result of the study were compared with their index performances and other investment instruments' performances. The evaluation performances of portfolios created in the study, especially taking into account the pandemic process, also enabled the measurement of the reflection of the hypothesis that small investors flocked to stock markets, which is frequently expressed in this process, on MV / BV, P / E and neglected company anomalies.

In this study, unlike previous studies, TOPSIS and GRA methods are used not only to measure the financial performance of companies, but also for portfolio creation. In the study, it is aimed to measure the performance of the portfolios created by TOPSIS and GRA methods in the next period, based on the previous period data of the companies. In this way, another aim of the study is to determine the resilience and success of portfolios created with TOPSIS and GRA methods, especially in crisis periods as in the pandemic period. In the next sectionsf the study, first, a literature review will be included. Then, the methodology of the study will be given, and in the last section the application and findings section will take place. The study ends with the conclusion part.

## 2. Literature Review

On March 11, 2020, with the World Health Organization (WHO) officially declaring that the coronavirus (COVID-19) epidemic was a global pandemic, significant fluctuations occurred in the global economy and financial markets. Significant upward movements in exchange rates and gold prices and in stock markets excessive volatility were observed. Since almost all countries worldwide have adopted strict quarantine policies with the pandemic, economic activities have been significantly disrupted. Large-scale movements have been observed in the financial markets. Mobilization has been declared to prevent sudden and drastic decreases and increases experienced in the world's leading stock markets at an unprecedented level in history. The uncertainty regarding the future of the pandemic process and economies continues today, despite the positive atmosphere observed in financial markets with the end of the effects of the first shocks, getting used to living with the pandemic and vaccination efforts. Although noticeable recovery is taking place around the world today, the effects of the negativities continue.

During the COVID-19 outbreak, many studies have been conducted on the impact of the epidemic on the economy and financial markets. These studies generally focused on the effect of the epidemic on stock market indices. Within this study's scope, the performances of the portfolios formed from low and high performing stocks in the previous periods in the context of stock market performance ratios were examined during the pandemic period.

There are many studies in the literature where rates and indicators such as Price/Earning (P/E) ratio, Market Value (MV)/Book Value (BV) ratio, dividend yield, trading volume, earnings per share are discussed, and the relationship between these ratios and stock returns and performance are examined.

Basu (1977; 1983) found that portfolios with a low P/E ratio get higher returns than securities with a high P/E ratio. Fuller, Hurberts, and Levinson (1992) determined that the ratio of earnings growth tends to be low in stocks with low price/earnings ratio and that the rate of earnings growth in stocks with high price/earnings ratio tends to be high. Reinganum (1981), Stafford, Fiore and Zuber (1989), Lakonishok, Shleifer and Vishny (1994), Karan (1996), Keun-Yeab, Bonghan and Honkee (2006), Aras and Yılmaz (2008), Horasan (2009), and Nargelecekenler (2011) have concluded that long-term investment in stocks with low P / E ratios can result in higher returns than stocks with high P / E ratios.

Düzer (2008), Horasan (2009) and Gemici (2010) found that P/E and MV/BV ratios significantly affect firm value. However, this effect differs from firm to firm. Horasan (2009) stated that the effect of the P/E ratio on the next period's closing prices is significant and positive, while its effect on the return is significantly negative. The price/earnings ratio should be high for existing

partners and low for potential investors. Based on potential investors' trust in the company, the price to be paid for the stock may increase (Asiri and Hameed, 2014). In the study conducted by Karadeniz and Koşan (2020), the average of companies' stock returns with a high price/earnings ratio was opposing. On the other hand, the stock returns of companies with low price/earnings ratio were positive. In this context, there was a statistically significant difference between the two groups.

Karadeniz and Koşan (2020) found a statistically significant difference between tourism companies with high and low price/earnings ratio in terms of stock returns. On the other hand, Hepsen & Demirci (2007), Akkoç et al. (2009), Cihangir and Karaağaç (2016) could not detect this anomaly in their studies on Borsa İstanbul. Moreover, Cihangir, Söker and Baysa (2019) could not detect P/E and MV/BV anomalies in Borsa Istanbul.

Fama and French (1992, 1993) found that stocks' expected returns are positively affected by the MV/BV ratio. Fama and French (1992, 1993) showed that the stocks of firms with low MV / BV tend to yield higher returns. Petkova and Zhang (2005), on the other hand, found that investors think stocks with low MV/BV are riskier in "bad" periods. While investors' confidence in businesses increases the MV/BV value, the fact that this ratio is above a certain optimal point is interpreted as an indicator that the stock is expensive, and the lower it is cheap. In companies with high market MV/BV ratio, the expected return is also high (Bayyurt, 2007: 587). Researchers such as Rouwenhorst (1999), Canbaş, Kandır and Erişmiş (2008), Kaya and Güngör (2018) found that stocks with lower P/D ratios outperform stocks with higher P / D ratios. Arbel et al. (1983), Carvell and Strebel (1987), Jahera and Lloyd (1989), Beard and Sias (1997), Li and Fleisher (2004), Akhter et al. (2015) and Sak and Dalgar (2020) found that the neglected company anomaly is valid at certain levels in their studies on the stock markets of different countries.

Başçı et al. (1996) found that there is a cointegration relationship between price and trading volume. Gökçe (2002) determined that the causal relationship between share price changes and trading volume is from price to trading volume. Mahajan and Singh (2008) found a positive relationship between trading volume and return. Uyar and Kangalli (2012) observed a rapid increase risk in the portfolios created with monthly and daily data on stocks with high trading volume and the increase in the expected return on the useful boundary charts of these portfolios. A rational investor preferred portfolios consisting of stocks with high trading volume. Yılmaz and Kaygın (2018) found a unidirectional causality from trading volume to the stock price in the BIST 30 index and from price to trading volume in the DAX 30 index.

Another important topic in finance literature is the dividend-stock price relationship. This issue has been frequently researched and continues to be

investigated from the past to the present. Miller and Modigliani (1961) argued that there is no relationship between companies' dividend policies and company value. On the other hand, researchers such as Gordon (1963) and Lintner (1962) put forward the "Bird Theory in Hand". They argued that investors would prefer the dividend, which they see like a bird in the hand, to the capital gain, the bird in the branch, because the future is uncertain and includes risk. Black and Scholes (1974) argued that there is no relationship between dividend policy and stock prices and that firms' dividend policies do not affect stock prices. Baskin (1989) found a significant negative relationship between dividend yield and stock prices. Allen and Rachim (1996) could not find a relationship between dividend yield and stock market price. Al-Shawawreh (2014) found a significant negative relationship between share price volatility and dividend payment and a fragile positive relationship between dividend yield and stock price volatility. Dividend yield indicates how much dividend a company pays its shareholders each year. Although dividends are usually paid in cash, they can also be paid in stocks and other financial assets. Hunjra et al. (2014) found that the dividend yield and dividend payment ratio effectively affect the share price. Arslan, Zaman, and Phil (2014) found a significant negative relationship between dividend yield and stock prices.

Black, Jensen, and Scholes (1972) and Miller and Scholes (1972) found that low beta stocks performed better than the capital asset pricing model (CAPM) predicted, while high beta stocks performed worse. Lakonishok and Shapiro (1986) reported that beta value could not explain the variation in returns. Fama and French (1990) expanded this finding until 1990. Fama and French (1990) argued that firm beta makes no contribution to the prediction of future returns when controlling for a set of widely followed characteristics of firms, such as market to book value.

Considering the recent studies on the subject; Dayı (2020) found that the returns on stocks are systematically affected by risk. Oral and Yılmaz (2017) determined a short and long-term relationship between the Borsa Istanbul Industrial Index and political risk. Astuty (2017) concluded that the systematic risk value affects the stock price significantly and negatively.

Some studies which use TOPSIS and GRA method in the context of financial ratios are summarized below.

Peker and Birdoğan (2011) reported companies operating in the insurance industry according to their financial performance. For this purpose, performance has been measured with the help of liquidity, leverage and profitability ratios by using GRA method. It is concluded that a company with high liquidity ratios may have a high financial performance.

Bektaş and Kadir (2013) carried out performance measurements for eleven enterprises traded in Borsa Istanbul Emerging Companies Market. For this, six ratios were obtained using the 2011 balance sheet and income statement data of the enterprises. GRA was applied using these ratios. As a result of the analysis, Denge Investment Holding has the highest performance. It has also been observed that DENGE has high profitability ratios, including net profit / total assets, net profit/equity, and net profit / net sales.

Salur and Cihan (2013) analyzed the financial performance of traditional and participation banks using TOPSIS method. According to the results, Akbank has been the most successful company. State banks ranked first in the ranking of success. Private banks are in the last place as banks such as Turkland Alternatifbank and Turkishbank and Fibabank have small volumes and limited banking tradings.

Karkacier and Yazgan (2017) evaluated the financial performances of ten tourism companies registered in Borsa Istanbul in 2015 using the GRA method. The findings showed that the leverage ratio emerged as the most critical ratio among the financial ratios used to measure tourism companies' financial performance. It was concluded that firm G has the highest performance.

Özçelik and Küçükçakal (2018) evaluated the financial performances of seven leasing and factoring companies traded on Borsa Istanbul, whose financial statements can be accessed without interruption in the 2009-2016 period, using the TOPSIS method according to six financial ratios. Financial performances of financial leasing and factoring companies operating in BIST were evaluated, and it was understood that CRDFA displayed a successful performance.

Kızıl (2019) investigated the relationship between financial performance and stock market performance in Borsa Istanbul. According to the results of the TOPSIS method analysis, they determined a significant relationship between the financial performance of cement factories and their stock market performances.

Abdel-Basset et al. (2020) evaluated the top 10 steel companies' performances in Egypt with the AHP, TOPSIS and VIKOR methods, according to financial ratios. Through the steel fabrication experts'opinions, the weight of the criteria is determined using the AHP method. Firm ranking is determined by using VIKOR and TOPSIS comparatively. The results show that the rankings of the companies obtained by these methods are almost the same.

Ünvan (2020) tried to determine the criteria that affect the financial performance in banks. For this purpose, performance evaluation was carried out by using TOPSIS and Fuzzy TOPSIS methods according to the reports received from the Banks Association of Turkey between the periods of 2014-2018. According to the results, both methods gave significant results. However, the difference in

approach in terms of the period evaluated by the two methods does not allow a one-to-one comparison of the financial performance of the banks.

Nguyen et al. (2020) aimed to rank the stocks of agricultural companies on the Vietnam Stock Exchange. Using the 2016-2019 period data, GRA, MOORA and TOPSIS methods were used. They used the AHP method to determine the weights of financial ratios. The results showed that HSL was the top stock with the highest ranking, and the GRA, MOORA and TOPSIS rankings had strong correlation values of 0.78-1.

Ban et al. (2020) ranked Romanian companies operating in the manufacturing industry according to their performance using eight financial and seven non-financial indicators. In their studies covering the period of 2011-2015, the weights of individual or indicator categories were calculated with the Fuzzy Analytical Hierarchy Process. Then, with the TOPSIS method, performance levels were obtained for each company separately for financial, non-financial and all indicators. According to the results, it was seen that non-financial indicators significantly affected the general performance of the companies for the analyzed period.

## 3. Methodology

TOPSIS and GRA methods are employed in this study. The detailed explanation of the methods are given below.

### 3.1. TOPSIS Method

The TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) method was first proposed by Hwang and Yoon (1981). It is a multi-criteria decision-making method that has been widely used in many fields. According to this technique, the best alternative will be the closest to the positive ideal solution and the furthest to the negative ideal solution (Benitez, Martin andRoman, 2007). The positive ideal solution is a solution that maximizes the benefit criteria and minimizes the cost criteria. In contrast, the negative ideal solution minimizes the benefit criteria by maximizing the cost criteria (Wang and Elhag, 2006). In short, the positive ideal solution consists of the best possible values of the criteria, and the negative ideal solution consists of the worst possible values of the criteria (Wang, 2007; Ertuğrul and Karakaşoğlu, 2009).

TOPSIS method is based on the principle of proximity to positive ideal solution and distance to negative ideal solution. The proximity of decision points to the ideal solution is the main principle.

In TOPSIS method, benefit or cost distinction is made among the criteria. If the criteria have different degrees of importance, the methods such as AHP, SWARA,

and ENTROPY are used to determine the criteria weights. TOPSIS method includes a solution process consisting of six steps (Özbek, 2017).

*Step 1: Creating the Decision Matrix*

Decision matrix $A_{ij}$ is created as the first step after determining decision-making units, criteria and criterion weights if any. *n* and *m* represent criteria and decision making unit number, respectively.

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

*Step 2: Normalization of Decision Matrix*

After the decision matrix is created, a normalized decision matrix is obtained using Equation (2).

$$r_{ij} = \frac{a_{ij}}{\sqrt{\sum_{k=1}^{m} a_{kj}^2}}, \; i = 1,....,m \qquad j = 1,.....,n \quad (2)$$

Normalized decision matrix $R_{ij}$ obtained after normalization process is given below.

$$R_{ij=}\begin{bmatrix} r_{11} & r_{12} & \cdots & r_{1n} \\ r_{21} & r_{22} & \cdots & r_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ r_{m1} & r_{m2} & \cdots & r_{mn} \end{bmatrix} \quad (3)$$

*Step 3: Creating the Weighted Normalized Decision Matrix*

Suppose the performance criteria used in the analysis have different degrees of importance. In that case, a weighted standard decision matrix is obtained by multiplying each column of the standard decision matrix with the specified weights. Otherwise, this step can be skipped if the criteria are of equal importance. The sum of the determined criteria weights must be equal to one.

$$\sum_{i=1}^{n} w_i = 1 \tag{4}$$

Then, the cells in each column of the *R* matrix are multiplied by their respective $w_i$ value to form the $V_{ij}$ matrix. The $V_{ij}$ matrix is shown below:

$$V_{ij=}\begin{bmatrix} w_1 r_{11} & w_2 r_{12} & \cdots & w_n r_{1n} \\ w_1 r_{21} & w_2 r_{22} & \cdots & w_n r_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ w_1 r_{m1} & w_2 r_{m2} & \cdots & w_n r_{mn} \end{bmatrix} \tag{5}$$

*Step 4: Determining the Positive (A*) and Negative (A-) Ideal Solutions*

The highest value of the weighted evaluation criteria (the smallest value if the relevant evaluation criteria is minimized) is selected for each column in the $V_{ij}$ matrix to determine the positive ideal solution set. The creation of the positive ideal solution set is shown in Equation (6).

$$A^* = \left\{ (\max_i v_{ij} \,\middle|\, j \in J), (\min_i v_{ij} \,\middle|\, j \in J' \right\}, A^* = \left\{ v_1^*, v_2^*, ..., v_n^* \right\} \tag{6}$$

The smallest value of the weighted evaluation criteria (the highest value if the relevant evaluation criteria are maximized) is selected for each column in the $V_{ij}$ matrix to determine the negative ideal solution set. The creation of the negative ideal solution set is shown in Equation (7).

$$A^- = \left\{ (\min_i v_{ij} \,\middle|\, j \in J), (\max_i v_{ij} \,\middle|\, j \in J' \right\}, A^- = \left\{ v_1^-, v_2^-, ..., v_n^- \right\} \tag{7}$$

In Equation 6 and 7 while *J* shows the benefit (maximization), $J'$ denotes to the cost (minimization) value. Both ideal and negative ideal solution set consist of *n* elements with the number of evaluation criteria.

*Step 5: Calculating the Positive and Negative Separation Measures Using Euclidean Distance*

The separation measures of each decision-making unit are calculated using Equation (8) and Equation (9) based on Euclidean distance.

$$S_i^* = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^*)^2}\ , \quad \forall i = 1, 2, ..., m \tag{8}$$

$$S_i^- = \sqrt{\sum_{j=1}^{n} (v_{ij} - v_j^-)^2}\ , \forall i = 1, 2, ..., m \tag{9}$$

Where $S_i^*$ denotes to the positive separation measures and $S_i^-$ represents the negative separation measures and $S_i^*, S_i^-$ will be calculated for each decision-making units.

*Step 6: Calculation of Relative Proximity to the Ideal Solution*

Positive ideal and negative ideal separation measures are used to calculate each decision point's relative proximity to the ideal solution. The criterion used here is the share of the negative ideal separation measurethe total separation measure (Erdin and Ozkaya, 2020). The calculation of the relative proximity $C_i^*$ to the ideal solution is shown in Equation (10).

$$C_i^* = \frac{S_i^-}{S_i^- + S_i^*}, 0 \le C_i^* \le 1 \tag{10}$$

$C*$ takes a value between 0 and 1. Value of 0 indicates that the decision unit is on the negative ideal solution point. Value of 1 indicates that the decision unit is on the positive ideal solution point. The decision unit with the highest $C*$ value is selected as the best performing decision unit.

3.2. Grey Relational Analysis

Grey system theory (GST), an interdisciplinary approach, was first proposed by Deng Julong in 1982. GST is an alternative method of expressing uncertainty with numbers. The basic idea in the emergence of the method is to predict uncertain system behaviors that cannot be solved by stochastic or fuzzy methods under a limited number of data. The GST was introduced to deal with situations with partly unknown or partly known information. In this theory, "white system" represents systems of which all information is known, "black system" when no information about the system is known and "grey system" represents partially informed systems (Özbek, 2017).

The grey relational analysis (GRA) method, which is an extension of the GST, is a method applied to obtain multi-criteria decision-making problems when limited data and decision-makers cannot have sufficient expertise. The grey relations gives information about the degree of relations between two subsystems within a

given system. Similarities or differences between the systems or decision units included in the analysis are expressed as "grey relations". In the GRA, the degree of relation between the two factors is obtained by comparing the factors geometrically. It is stated that the closer the factors are geometrically, the stronger the relationship between them (Köse, 2020).

As with the TOPSIS method, the GRA is based on measuring the optimum value of the distance to reach an ideal solution. GRA is a method for determining the degree of relationship between each factor in a grey system and the compared reference sequence.

The main procedure of GRA is firstly transforming the performances of all alternatives into an identical sequence. This step is called as grey relational generating. According to identical sequences, a reference sequence (target sequence) is defined. Then, the relational coefficients between all sequences and reference sequence are calculated. In the end, based on these grey relational coefficients, the grey relation grades between the reference sequence and each identical sequence are calculated. An alternative that has the highest grey relational grade will be the best choice (Kuo, Yang and Huang, 2008).

The grey relational analysis consists of three stages: First, the comparison matrix and reference sequence are created. Second, the normalized and absolute value matrix are calculated. Finally, grey relational coefficients are calculated, and then grey relational grades are generated. All the steps of the method are as shown below (Özbek, 2017):

*Step 1: Creating the Comparison Matrix and Determining the Reference Sequence*

Let us assume that there are *m* alternatives and *n* criteria in the decision process. Factor sequence, comparison or decision matrix and reference sequence are created as shown below in Equation (11), Equation (12) and Equation (13) respectively:

$$x_i = (x_i(j), ..., x_i(n)), i = 1, 2, ..., m;\ j = 1, 2, ..., n \tag{11}$$

$$X = \begin{bmatrix} x_1(1) & x_1(2) & \cdots & x_1(n) \\ x_2(1) & x_2(2) & \cdots & x_2(n) \\ \vdots & \vdots & \ddots & \vdots \\ x_m(1) & x_m(2) & \cdots & x_m(n) \end{bmatrix} \tag{12}$$

After the comparison matrix is created, a reference sequence is created from each factor's best values, as shown in equation (13). This reference sequence is added

as a new row on the top of the comparison matrix. The best value means the highest value for beneficial factors and means the lowest value for non-beneficial factors. $x_0(j)$ means the optimum value for each factor in the comparison matrix.

$$x_0 = (x_0(j)),\ j = 1, 2, ..., n \tag{13}$$

*Step 2: Normalization Process and Calculating the Absolute Value Matrix*

Considering that factors may consist of different measurement units during the calculation of grey relational coefficients, the data should be standardized. This process is called normalization. The normalization process varies according to the beneficial (the more is better), non-beneficial (the less is better) or optimum criteria. The formula for beneficial, non-beneficial and optimum criteria is given below in Equation (14), (15) and (16) respectively.

$$x_i^* = \frac{x_i(j) - \min_j x_i(j)}{\max_j x_i(j) - \min_j x_i(j)} \tag{14}$$

$$x_i^* = \frac{\max_j x_i(j) - x_i(j)}{\max_j x_i(j) - \min_j x_i(j)} \tag{15}$$

$$x_i^* = \frac{\left| x_i(j) - x_{0b}(j) \right|}{\max_j x_i(j) - x_{0b}(j)} \tag{16}$$

The $x_{0b}$ in equation (16) means that the optimum and target value of the factor $j$ and ranges between $\max_j x_i(j)$ and $\min_j x_i(j)$. After this process, the normalization matrix is created, as shown in Equation (17).

$$X_i^* = \begin{bmatrix} x_1^*(1) & x_1^*(2) & \cdots & x_1^*(n) \\ x_2^*(1) & x_2^*(2) & \cdots & x_2^*(n) \\ \vdots & \vdots & \ddots & \vdots \\ x_m^*(1) & x_m^*(2) & \cdots & x_m^*(n) \end{bmatrix} \tag{17}$$

This step's final process is the calculation of the absolute value matrix by using the normalization matrix created in equation (17). The calculation of the absolute value matrix is given in Equation (18) below.

$$\Delta_{0i} = \left| x_0^*(j) - x_i^*(j) \right|, i = 1,2,...,m;\ j = 1,2,...,n \tag{18}$$

The absolute value matrix used in the calculation of grey relational coefficients is shown in Equation (19).

$$X_i^* = \begin{bmatrix} \Delta_{01}(1) & \Delta_{01}(2) & \cdots & \Delta_{01}(n) \\ \Delta_{02}(1) & \Delta_{02}(2) & \cdots & \Delta_{02}(n) \\ \vdots & \vdots & \ddots & \vdots \\ \Delta_{0m}(1) & \Delta_{0m}(2) & \cdots & \Delta_{0m}(n) \end{bmatrix} \tag{19}$$

*Step 3: Calculating the Grey Relational Coefficients and Grey Relational Grades*

In order to determine how close $X_{ij}$ and $X_{0j}$, the grey relational coefficient is used to reveal the difference. The greater value of the grey relational coefficient, the closer is $X_{ij}$ and $X_{0j}$. The grey relational coefficients between $X_{ij}$ and $X_{0j}$ are calculated by Equation (20).

$$\begin{aligned} \gamma_{0i}(j) &= \frac{\Delta_{\min} + \zeta\Delta_{\max}}{\Delta_{0i} + \zeta\Delta_{\max}}, \zeta \in [0,1] \\ \Delta_{\min} &= \min\left\{\Delta_{ij}, i = 1,2,...,m;\ j = 1,2,...,n\right\} \\ \Delta_{\max} &= \max\left\{\Delta_{ij}, i = 1,2,...,m;\ j = 1,2,...,n\right\} \end{aligned} \tag{20}$$

The distinguished coefficient ($\zeta$) is used to expand or compress the grey relational coefficient range. For this study, the distinguishing coefficient is assumed as 0.5 (Cheng et al., 2021).

After the grey relational coefficients are determined, the grey relational grades are calculated using Equation (21) or (22). The grey relational grade shows how similar the series being compared to the reference sequence. However, this process depends on whether the factors are of equal importance. Equation (21) is used if the factors are of equal importance and Equation (22) if they are of different importance.

$$\Gamma_{0i} = \frac{1}{n}\sum_{j=1}^{n} \gamma_{0i}(j), i = 1,2,...,m \tag{21}$$

$$\Gamma_{0i} = \frac{1}{n}\sum_{j=1}^{n}\left[w_i(j)\gamma_{0i}(j)\right], i = 1, 2, ..., m \quad (22)$$

The grey relational grade is a measure of the geometric similarity between the comparable sequence $(x_i^*)$ and the reference sequence $(x_0^*)$, allowing the sequences to be compared. The higher value shows that there is a strong relationship between the two sequences. The decision unit with the highest grey relational grade will be the best performing decision unit (Özbek, 2017).

## 4. Application and Findings

In this study, four portfolios were created based on TOPSIS and Grey Relational Analysis (GRA) methods, stock market performance ratios and other fundamental financial indicators considered in stock investment, based on companies operating in three different sectors, namely Banks (XBANK), Wholesale & Retail Trade (XTCRT) and Textile & Leather (XTEKS). For the period 06.02.2021-05.02.2021, these portfolios' performance has been determined in comparison with stock indices and other investment instruments. TOPSIS and GRA methods were used to determine the companies with the highest and lowest performance based on the financial indicators included in the study. Another aim of this study is to test the effectiveness and success of TOPSIS and GRA methods in portfolio creation. This study is also aimed to test MV/BV, P/E and neglected company anomalies during the pandemic process. For these purposes, in addition to MV/BV, P/E, dividend yield (DY) and trading volume (TV) variables, which investors frequently use in stock investments and are considered as stock market performance indicators, risk (BETA), earnings per share (EPS) return on equity (ROE) variables are used. The variables used in the study are given in Table 1.

**Table 1. Variables used in the Study**

| Financial Indicator | Abbreviation | Calculation |
|---|---|---|
| Market Value / Book Value | MV/BV | Market Value of the Stock / Equity |
| Price / Earnings | P/E | Stock Price / Earnings Per Share |
| Trading Volume | TV | The monetary value of all purchases and sales in the stock |
| Dividend Yield | DY | Dividend Per Share / Share Price |
| Systematic Risk | BETA | Percentage change in stock price/percentage change in the market index |
| Earnings per share | EPS | Net Profit / Total Number of Shares |
| Return on Equity | ROE | Net Profit / Equity |

In the analysis part of the study, applications on the banking sector are given systematically as an example for the year 2019. Only comparison and results tables of other sectors and years are presented. In this study, based on the

literature summarized above, the P/E and MV/BV ratios were analyzed first as normal (directly proportional to performance) and then as inverse (inversely proportional to performance) variables in order to compare and evaluate their effect on portfolio returns in both cases. Since BETA expresses risk, it is considered as an inverse variable. Tables resulting from the steps of TOPSIS and Grey Relational Analysis methods are given below in the context of the banking sector example.

### 4.1. TOPSIS Results

The first step of the TOPSIS method is creating a decision matrix using data. The first row in Table 2 shows the type of criteria in terms of beneficial (max) or non-beneficial (min).

**Table 2. TOPSIS Decision Matrix**

| | Max | Max | Max | Max | Max | Min | Max |
|---|---|---|---|---|---|---|---|
| | **ROE** | **P/E** | **MV/BV** | **DY** | **EPS** | **BETA** | **TV** |
| Akbank | 11,29 | 6,56 | 0,68 | 3,61 | 1,01 | 1,05 | 256765642 |
| Albaraka | -0,84 | 10,98 | 0,37 | 2,85 | -0,04 | 1,42 | 15080972 |
| Garanti | 13,01 | 5,85 | 0,71 | 3,70 | 1,48 | 1,27 | 696913910 |
| ICBCT | 3,53 | 77,93 | 2,56 | 0,00 | 0,05 | 1,83 | 50892612 |
| İs Bankası | 12,10 | 4,18 | 0,47 | 4,15 | 1,35 | 0,86 | 183476138 |
| QNB Finans | 17,72 | 20,47 | 3,34 | 0,24 | 0,77 | 3,53 | 17435468 |
| Sekerbank | -13,40 | 0,00 | 0,52 | 0,00 | -0,26 | 1,55 | 18267001 |
| Halkbank | 5,37 | 4,96 | 0,24 | 2,07 | 1,25 | 0,48 | 223686139 |
| TSKB | 9,35 | 2,43 | 1,00 | 0,00 | 0,04 | 1,47 | 930683 |
| Vakıfbank | 10,78 | 3,85 | 0,38 | 0,89 | 1,22 | 0,84 | 167737289 |
| Yapı Kredi | 11,20 | 4,27 | 0,46 | 0,00 | 0,51 | 0,82 | 159768919 |

After the decision matrix created, all the data needs to be normalized by using equation (1). The normalized decision matrix is shown in Table 3.

**Table 3. TOPSIS Normalized Decision Matrix**

| | Max | Max | Max | Max | Max | Min | Max |
|---|---|---|---|---|---|---|---|
| | **ROE** | **P/E** | **MV/BV** | **DY** | **EPS** | **BETA** | **TV** |
| Akbank | 0,3122 | 0,0797 | 0,1504 | 0,4773 | 0,3369 | 0,2000 | 0,3086 |
| Albaraka | -0,0231 | 0,1335 | 0,0815 | 0,3765 | -0,0124 | 0,2720 | 0,0181 |
| Garanti | 0,3597 | 0,0711 | 0,1570 | 0,4891 | 0,4940 | 0,2417 | 0,8375 |
| ICBCT | 0,0977 | 0,9471 | 0,5622 | 0,0000 | 0,0160 | 0,3486 | 0,0612 |
| İs Bankası | 0,3347 | 0,0508 | 0,1027 | 0,5493 | 0,4498 | 0,1651 | 0,2205 |
| QNB Finans | 0,4901 | 0,2488 | 0,7338 | 0,0318 | 0,2566 | 0,6735 | 0,0210 |
| Sekerbank | -0,3705 | 0,0000 | 0,1152 | 0,0000 | -0,0852 | 0,2961 | 0,0220 |
| Halkbank | 0,1484 | 0,0603 | 0,0532 | 0,2734 | 0,4156 | 0,0918 | 0,2688 |
| TSKB | 0,2586 | 0,0295 | 0,2191 | 0,0000 | 0,0141 | 0,2803 | 0,0011 |
| Vakıfbank | 0,2981 | 0,0468 | 0,0827 | 0,1172 | 0,4058 | 0,1609 | 0,2016 |
| Yapı Kredi | 0,3097 | 0,0519 | 0,1006 | 0,0000 | 0,1701 | 0,1569 | 0,1920 |

The criteria that included in this study have equal importance. Therefore, the weighted normalized decision matrix will be same with the normalized decision

matrix. After this step, according to the specified criteria, the positive and negative ideal solution points consisting of the highest and lowest values of the decision units are given in Table 4. If the criteria are considered as beneficial or maximum, the highest values are selected in each column as positive ideal solutions. However, if the criteria are considered non-beneficial, cost or minimum, the lowest values are selected in each column as negative ideal solutions.

**Table 4. Positive and Negative Ideal Solutions**

| | Max | Max | Max | Max | Max | Min | Max |
|---|---|---|---|---|---|---|---|
| | **ROE** | **P/E** | **MV/BV** | **DY** | **EPS** | **BETA** | **TV** |
| **PIS** | 0,4901 | 0,9471 | 0,7338 | 0,5493 | 0,4940 | 0,0918 | 0,8375 |
| **NIS** | -0,3705 | 0,0000 | 0,0532 | 0,0000 | -0,0852 | 0,6735 | 0,0011 |

Since TOPSIS is a method that offers solutions based on the distance, the distances of the decision units to the best (positive ideal) and worst (negative ideal) solutions should be calculated after the normalized matrix is obtained and PIS and NIS are determined. The separation measures calculated using equation (8) and (9) are shown in Table 5. After separation measures calculated, the last step is determining the relative proximities to the ideal solutions by using equation (10) and making a performance ranking. The results are also given in Table 5.

**Table 5. Separation Measures and Ranking**

| | $S^+$ | $S^-$ | $C^*$ | **TOPSIS Ranking** |
|---|---|---|---|---|
| Akbank | 1,2024 | 1,0984 | 0,4774 | 4 |
| Albaraka | 1,5300 | 0,6692 | 0,3043 | 10 |
| **Garanti** | **1,0692** | **1,4176** | **0,5701** | **1** |
| ICBCT | 1,1757 | 1,2226 | 0,5098 | 2 |
| İs Bankası | 1,2703 | 1,1819 | 0,4820 | 3 |
| QNB Finans | 1,3480 | 1,1764 | 0,4660 | 5 |
| Sekerbank | 1,8342 | 0,3831 | 0,1728 | 11 |
| Halkbank | 1,3312 | 1,0042 | 0,4300 | 6 |
| TSKB | 1,5580 | 0,7672 | 0,3300 | 9 |
| Vakıfbank | 1,3692 | 1,0039 | 0,4230 | 7 |
| Yapı Kredi | 1,4361 | 0,9144 | 0,3890 | 8 |

As it can be seen in Table 5, Garanti Bank found as the best bank for the year 2019 according to the comparative data and criteria. After the TOPSIS method applied, Grey Relational Analysis (GRA) method also applied to the data to compare with the TOPSIS results.

4.2. Grey Relational Analysis Results

The GRA method's first step is to create a reference sequence and comparison matrix given in Table 6. As with the TOPSIS method, the first row in Table 6 shows the criteria for beneficial (max) or non-beneficial (min).

**Table 6. Grey Relational Analysis Reference Sequence and Comparison Matrix**

| | Max | Max | Max | Max | Max | Min | Max |
|---|---|---|---|---|---|---|---|
| | **ROE** | **P/E** | **MV/BV** | **DY** | **EPS** | **BETA** | **TV** |
| **Reference** | 17,72 | 77,93 | 3,34 | 4,15 | 1,48 | 0,48 | 696913910 |
| Akbank | 11,29 | 6,56 | 0,68 | 3,61 | 1,01 | 1,05 | 256765642 |
| Albaraka | -0,84 | 10,98 | 0,37 | 2,85 | -0,04 | 1,42 | 15080972 |
| Garanti | 13,01 | 5,85 | 0,71 | 3,70 | 1,48 | 1,27 | 696913910 |
| ICBCT | 3,53 | 77,93 | 2,56 | 0,00 | 0,05 | 1,83 | 50892612 |
| İs Bankası | 12,10 | 4,18 | 0,47 | 4,15 | 1,35 | 0,86 | 183476138 |
| QNB Finans | 17,72 | 20,47 | 3,34 | 0,24 | 0,77 | 3,53 | 17435468 |
| Sekerbank | -13,40 | 0,00 | 0,52 | 0,00 | -0,26 | 1,55 | 18267001 |
| Halkbank | 5,37 | 4,96 | 0,24 | 2,07 | 1,25 | 0,48 | 223686139 |
| TSKB | 9,35 | 2,43 | 1,00 | 0,00 | 0,04 | 1,47 | 930683 |
| Vakıfbank | 10,78 | 3,85 | 0,38 | 0,89 | 1,22 | 0,84 | 167737289 |
| Yapı Kredi | 11,20 | 4,27 | 0,46 | 0,00 | 0,51 | 0,82 | 159768919 |

After creating a reference sequence and comparison matrix, the next stage is transforming the data between 0-1 using equation (14) and equation (15). This process called normalizing, and it is done because criteria contain different units. The results are given in Table 7.

**Table 7. Grey Relational Analysis Normalized Decision Matrix**

| | Max | Max | Max | Max | Max | Min | Max |
|---|---|---|---|---|---|---|---|
| | **ROE** | **P/E** | **MV/BV** | **DY** | **EPS** | **BETA** | **TV** |
| **Reference** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Akbank | 0,7932 | 0,0841 | 0,1429 | 0,8689 | 0,7289 | 0,8140 | 0,3676 |
| Albaraka | 0,4036 | 0,1409 | 0,0417 | 0,6854 | 0,1258 | 0,6903 | 0,0203 |
| Garanti | 0,8484 | 0,0751 | 0,1525 | 0,8903 | 1,0000 | 0,7424 | 1,0000 |
| ICBCT | 0,5440 | 1,0000 | 0,7479 | 0,0000 | 0,1748 | 0,5585 | 0,0718 |
| İs Bankası | 0,8194 | 0,0536 | 0,0728 | 1,0000 | 0,9238 | 0,8741 | 0,2623 |
| QNB Finans | 1,0000 | 0,2627 | 1,0000 | 0,0579 | 0,5902 | 0,0000 | 0,0237 |
| Sekerbank | 0,0000 | 0,0000 | 0,0911 | 0,0000 | 0,0000 | 0,6489 | 0,0249 |
| Halkbank | 0,6029 | 0,0637 | 0,0000 | 0,4977 | 0,8647 | 1,0000 | 0,3201 |
| TSKB | 0,7310 | 0,0311 | 0,2439 | 0,0000 | 0,1715 | 0,6759 | 0,0000 |
| Vakıfbank | 0,7769 | 0,0495 | 0,0434 | 0,2134 | 0,8478 | 0,8812 | 0,2397 |
| Yapı Kredi | 0,7904 | 0,0548 | 0,0697 | 0,0000 | 0,4409 | 0,8881 | 0,2282 |

In the step following the normalization process, the absolute value matrix must be created by using the equation (18) as shown in Table 8. In this step, the reference sequence is consist of the highest value of each column.

**Table 8. Grey Relational Analysis Absolute Value Matrix**

| | Max | Max | Max | Max | Max | Min | Max |
|---|---|---|---|---|---|---|---|
| | **ROE** | **P/E** | **MV/BV** | **DY** | **EPS** | **BETA** | **TV** |
| **Reference** | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Akbank | 0,2068 | 0,9159 | 0,8571 | 0,1311 | 0,2711 | 0,1860 | 0,6324 |
| Albaraka | 0,5964 | 0,8591 | 0,9583 | 0,3146 | 0,8742 | 0,3097 | 0,9797 |
| Garanti | 0,1516 | 0,9249 | 0,8475 | 0,1097 | 0,0000 | 0,2576 | 0,0000 |
| ICBCT | 0,4560 | 0,0000 | 0,2521 | 1,0000 | 0,8252 | 0,4415 | 0,9282 |
| İs Bankası | 0,1806 | 0,9464 | 0,9272 | 0,0000 | 0,0762 | 0,1259 | 0,7377 |
| QNB Finans | 0,0000 | 0,7373 | 0,0000 | 0,9421 | 0,4098 | 1,0000 | 0,9763 |
| Sekerbank | 1,0000 | 1,0000 | 0,9089 | 1,0000 | 1,0000 | 0,3511 | 0,9751 |
| Halkbank | 0,3971 | 0,9363 | 1,0000 | 0,5023 | 0,1353 | 0,0000 | 0,6799 |
| TSKB | 0,2690 | 0,9689 | 0,7561 | 1,0000 | 0,8285 | 0,3241 | 1,0000 |
| Vakıfbank | 0,2231 | 0,9505 | 0,9566 | 0,7866 | 0,1522 | 0,1188 | 0,7603 |
| Yapı Kredi | 0,2096 | 0,9452 | 0,9303 | 1,0000 | 0,5591 | 0,1119 | 0,7718 |

In the last step, the grey relational coefficients matrix and grades of grey relations need to be calculated to rank decision units. The grey relational coefficients are calculated using equation (20) and grey relational grades are calculated using equation (21) as given in Table 9. As in the TOPSIS method, in the GRA method, the Garanti bank was the best performing bank in 2019 according to the determined criteria.

**Table 9. Grey Relational Coefficients Matrix and Grades of Grey Relations**

| | Max | Max | Max | Max | Max | Min | Max | | |
|---|---|---|---|---|---|---|---|---|---|
| | **ROE** | **P/E** | **MV/BV** | **DY** | **EPS** | **BETA** | **TV** | **GR** | **Ranking** |
| Akbank | 0,7074 | 0,3531 | 0,3684 | 0,7922 | 0,6484 | 0,7289 | 0,4415 | 0,5771 | 3 |
| Albaraka | 0,4561 | 0,3679 | 0,3429 | 0,6138 | 0,3639 | 0,6175 | 0,3379 | 0,4428 | 9 |
| **Garanti** | **0,7674** | **0,3509** | **0,3711** | **0,8201** | **1,0000** | **0,6600** | **1,0000** | **0,7099** | **1** |
| ICBCT | 0,5230 | 1,0000 | 0,6648 | 0,3333 | 0,3773 | 0,5311 | 0,3501 | 0,5399 | 6 |
| İs Bankası | 0,7346 | 0,3457 | 0,3503 | 1,0000 | 0,8677 | 0,7988 | 0,4040 | 0,6430 | 2 |
| QNB Fin. | 1,0000 | 0,4041 | 1,0000 | 0,3467 | 0,5496 | 0,3333 | 0,3387 | 0,5675 | 4 |
| Sekerbank | 0,3333 | 0,3333 | 0,3549 | 0,3333 | 0,3333 | 0,5875 | 0,3390 | 0,3735 | 11 |
| Halkbank | 0,5574 | 0,3481 | 0,3333 | 0,4989 | 0,7870 | 1,0000 | 0,4237 | 0,5641 | 5 |
| TSKB | 0,6502 | 0,3404 | 0,3980 | 0,3333 | 0,3764 | 0,6067 | 0,3333 | 0,4341 | 10 |
| Vakıfbank | 0,6914 | 0,3447 | 0,3433 | 0,3886 | 0,7666 | 0,8080 | 0,3967 | 0,5342 | 7 |
| Yapı Kre. | 0,7046 | 0,3460 | 0,3496 | 0,3333 | 0,4721 | 0,8171 | 0,3932 | 0,4880 | 8 |

The results of the TOPSIS and GRA methods applied only to the 2019 data are given above. The results obtained for the other years using similar steps are shown in Table 10 comparatively.

**Table 10. Comparison of TOPSIS and GRA Results**

| | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Banks** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** |
| Akbank | 4 | 6 | 5 | 4 | 4 | 3 | 3 | 5 | 4 | 3 |
| Albaraka | 5 | 4 | 7 | 7 | 9 | 7 | 9 | 8 | 10 | 9 |
| **Garanti** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** |
| ICBCT | 10 | 11 | 4 | 5 | 2 | 5 | 2 | 4 | 2 | 6 |
| İs Bankası | 3 | 5 | 3 | 3 | 5 | 4 | 4 | 3 | 3 | 2 |
| QNB Fin. | 8 | 3 | 9 | 9 | 8 | 9 | 8 | 9 | 5 | 4 |
| Sekerbank | 9 | 9 | 11 | 11 | 10 | 10 | 10 | 10 | 11 | 11 |
| Halkbank | 2 | 2 | 2 | 2 | 3 | 2 | 5 | 2 | 6 | 5 |
| TSKB | 11 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 9 | 10 |
| Vakıfbank | 6 | 8 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 |
| Yapı Kre. | 7 | 7 | 8 | 8 | 7 | 8 | 7 | 7 | 8 | 8 |

**Table 11. Comparison of TOPSIS and GRA Results (FK, MV/BV Reverse)**

| | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | |
|---|---|---|---|---|---|---|---|---|---|---|
| **Banks** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** |
| Akbank | 6 | 8 | 4 | 7 | 4 | 4 | 2 | 4 | 3 | 4 |
| Albaraka | 4 | 2 | 7 | 4 | 7 | 6 | 7 | 7 | 8 | 7 |
| **Garanti** | **1** | **3** | **1** | **2** | **1** | **2** | **1** | **1** | **1** | **1** |
| ICBCT | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| İs Bankası | 3 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 |
| QNB Fin. | 9 | 9 | 10 | 10 | 8 | 10 | 8 | 9 | 9 | 10 |
| Sekerbank | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 8 | 10 | 9 |
| Halkbank | 2 | 1 | 2 | 1 | 2 | 1 | 4 | 2 | 4 | 3 |
| TSKB | 8 | 4 | 8 | 6 | 10 | 7 | 10 | 10 | 7 | 8 |
| Vakıfbank | 5 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| Yapı Kre. | 7 | 7 | 6 | 8 | 6 | 8 | 6 | 6 | 6 | 6 |

The results of the analyzes performed by following the above steps using TOPSIS and GRA methods are given in Table 12. Analyzes were performed based on three different sectors and the P/E ratio and MV/BV ratios were run both normal (positive if the ratio is higher) and reverse (the lower the ratio is more positive). The BETA variable was run the only inverse.

In the study, according to both methods, the observed rank values for 5 years were accepted as the 5-year success rank of that company. Therefore, integer values of mean rank values (as in seen Rank column in Table 12) rounded up and down were used to reach a decision. Considering the analysis results, the company with the highest stock market performance in the banking sector was Garanti in both methods. The lowest company was TSKB in the first place and ICBCT in the second. In the retail and wholesale trade sector, the highest company was BİM in both cases, while TEKNOSA was the first and MİGROS in the second. Looking at the textile sector, KORDSA was in the first case, and BİLİCİ was the companies with the highest stock market performance in the second. The lowest company was SÖKTAŞ in both cases.

## Table 12. Rankings Based on TOPSIS and GRA Methods

Comparison of TOPSIS and GRA Results

| Banks | 2015 | | 2016 | | 2017 | | 2018 | | 2019 | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | Rank |
| Akbank | 4 | 6 | 5 | 4 | 4 | 3 | 3 | 5 | 4 | 3 | 4,1 |
| Albaraka | 5 | 4 | 7 | 7 | 9 | 7 | 9 | 8 | 10 | 9 | 7,5 |
| Garanti | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | **1** | 1 | 1 |
| ICBCT | 10 | 11 | 4 | 5 | 2 | 5 | 2 | 4 | 2 | 6 | 5,1 |
| İs Bankası | 3 | 5 | 3 | 3 | 5 | 4 | 4 | 3 | 3 | 2 | 3,5 |
| QNB Fin. | 8 | 3 | 9 | 9 | 8 | 9 | 8 | 9 | 5 | 4 | 7,2 |
| Sekerbank | 9 | 9 | 11 | 11 | 10 | 10 | 10 | 10 | 11 | 11 | 10,2 |
| Halkbank | 2 | 2 | 2 | 2 | 3 | 2 | 5 | 2 | 6 | 5 | 3,1 |
| TSKB | 11 | 10 | 10 | 10 | 11 | 11 | 11 | 11 | 9 | 10 | 10,4 |
| Vakıfbank | 6 | 8 | 6 | 6 | 6 | 6 | 6 | 6 | 7 | 7 | 6,4 |
| Yapı Kredi | 7 | 7 | 8 | 8 | 7 | 8 | 7 | 7 | 8 | 8 | 7,5 |

Comparison of TOPSIS and GRA Results (P/E & M/B Reverse)

| Banks | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Akbank | 6 | 8 | 4 | 7 | 4 | 4 | 2 | 4 | 3 | 4 | 4,6 |
| Albaraka | 4 | 2 | 7 | 4 | 7 | 6 | 7 | 7 | 8 | 7 | 5,9 |
| Garanti | 1 | 3 | 1 | 2 | 1 | 2 | 1 | 1 | 1 | 1 | 1,4 |
| ICBCT | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 | 11 |
| İs Bankası | 3 | 5 | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 2 | 3 |
| QNB Fin. | 9 | 9 | 10 | 10 | 8 | 10 | 8 | 9 | 9 | 10 | 9,2 |
| Sekerbank | 10 | 10 | 9 | 9 | 9 | 9 | 9 | 8 | 10 | 9 | 9,2 |
| Halkbank | 2 | 1 | 2 | 1 | 2 | 1 | 4 | 2 | 4 | 3 | 2,2 |
| TSKB | 8 | 4 | 8 | 6 | 10 | 7 | 10 | 10 | 7 | 8 | 7,8 |
| Vakıfbank | 5 | 6 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5,1 |
| Yapı Kredi | 7 | 7 | 6 | 8 | 6 | 8 | 6 | 6 | 6 | 6 | 6,6 |

Comparison of TOPSIS and GRA Results

| Retail and Wholesale | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bim | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| Adese | 6 | 6 | 5 | 7 | 8 | 8 | 6 | 7 | 5 | 6 | 6,4 |
| Migros | 9 | 8 | 6 | 4 | 2 | 2 | 9 | 9 | 9 | 4 | 6,2 |
| Doğuş Oto | 2 | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 2 | 3 | 2,3 |
| Metro | 4 | 5 | 4 | 5 | 5 | 5 | 8 | 8 | 7 | 9 | 6 |
| Vakko | 7 | 9 | 7 | 8 | 4 | 4 | 3 | 4 | 3 | 2 | 5,1 |
| Teknosa | 8 | 7 | 9 | 9 | 9 | 9 | 5 | 3 | 8 | 8 | 7,5 |
| Bizim | 3 | 4 | 3 | 3 | 7 | 7 | 4 | 5 | 4 | 5 | 4,5 |
| Milpa | 5 | 3 | 8 | 6 | 6 | 6 | 7 | 6 | 6 | 7 | 6 |

Comparison of TOPSIS and GRA Results (P/E & M/B Reverse)

| Retail and Wholesale | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | TOPSIS | GRA | Rank |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Bim | 2 | 1 | 2 | 1 | 3 | 1 | 1 | 1 | 1 | 1 | 1,4 |
| Adese | 3 | 4 | 3 | 3 | 7 | 8 | 4 | 4 | 3 | 3 | 4,2 |
| Migros | 9 | 8 | 8 | 9 | 1 | 2 | 9 | 9 | 9 | 9 | 7,3 |
| Doğuş Oto | 1 | 2 | 1 | 2 | 2 | 3 | 2 | 2 | 8 | 8 | 3,1 |
| Metro | 5 | 7 | 4 | 5 | 8 | 9 | 8 | 8 | 7 | 7 | 6,8 |
| Vakko | 4 | 3 | 6 | 6 | 5 | 6 | 3 | 3 | 2 | 2 | 4 |
| Teknosa | 8 | 6 | 9 | 8 | 4 | 4 | 7 | 6 | 6 | 4 | 6,2 |
| Bizim | 7 | 9 | 7 | 7 | 9 | 5 | 5 | 7 | 4 | 6 | 6,6 |
| Milpa | 6 | 5 | 5 | 4 | 6 | 7 | 6 | 5 | 5 | 5 | 5,4 |

**Table 12 (Continued). Rankings Based on TOPSIS and GRA Methods**

| Comparison of TOPSIS and GRA Results | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **Textile** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **Rank** |
| Yataş | 8 | 8 | 7 | 5 | 1 | 1 | 1 | 1 | 4 | 3 | 3,9 |
| Kordsa | 3 | 2 | 1 | 1 | 2 | 2 | 3 | 4 | 2 | 1 | 2,1 |
| Menderes | 11 | 11 | 9 | 9 | 4 | 5 | 11 | 10 | 11 | 11 | 9,2 |
| Yunsa | 5 | 1 | 11 | 10 | 11 | 11 | 4 | 6 | 3 | 4 | 6,6 |
| Bossa | 7 | 7 | 5 | 2 | 5 | 6 | 2 | 3 | 5 | 5 | 4,7 |
| Arsan | 2 | 3 | 8 | 8 | 7 | 7 | 8 | 7 | 8 | 8 | 6,6 |
| Bilici Yatırım | 6 | 4 | 4 | 4 | 3 | 3 | 6 | 2 | 1 | 2 | 3,5 |
| Derimod | 9 | 9 | 6 | 7 | 9 | 9 | 9 | 8 | 10 | 10 | 8,6 |
| Dagi | 10 | 6 | 10 | 6 | 10 | 10 | 10 | 11 | 9 | 9 | 9,1 |
| Akın Tekstil | 1 | 5 | 3 | 3 | 6 | 4 | 5 | 5 | 6 | 6 | 4,4 |
| Söktaş | 12 | 10 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 12 | 11,8 |
| Hatay Tekstil | 4 | 12 | 2 | 11 | 8 | 8 | 7 | 9 | 7 | 7 | 7,5 |
| Comparison of TOPSIS and GRA Results (P/E & M/B Reverse) | | | | | | | | | | | |
| **Textile** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **TOPSIS** | **GRA** | **Rank** |
| Yataş | 7 | 9 | 7 | 9 | 4 | 6 | 3 | 3 | 5 | 6 | 5,9 |
| Kordsa | 3 | 6 | 1 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 2,2 |
| Menderes | 10 | 4 | 8 | 4 | 2 | 3 | 10 | 8 | 9 | 8 | 6,6 |
| Yunsa | 8 | 10 | 10 | 10 | 11 | 11 | 4 | 6 | 6 | 10 | 8,6 |
| Bossa | 5 | 5 | 5 | 7 | 9 | 12 | 6 | 10 | 3 | 3 | 6,5 |
| Arsan | 2 | 2 | 6 | 5 | 6 | 5 | 7 | 5 | 8 | 5 | 5,1 |
| Bilici Yatırım | 4 | 3 | 3 | 1 | 3 | 1 | 2 | 1 | 1 | 1 | 2 |
| Derimod | 6 | 8 | 4 | 6 | 8 | 10 | 8 | 11 | 12 | 12 | 8,5 |
| Dagi | 9 | 11 | 9 | 11 | 7 | 6 | 9 | 7 | 10 | 11 | 9 |
| Akın Tekstil | 1 | 1 | 2 | 3 | 10 | 9 | 11 | 9 | 7 | 6 | 5,9 |
| Söktaş | 11 | 7 | 11 | 8 | 12 | 8 | 12 | 12 | 11 | 9 | 10,1 |
| Hatay Tekstil | 12 | 12 | 12 | 12 | 5 | 4 | 5 | 4 | 4 | 4 | 7,4 |

In the next stage of the study, portfolios were created by taking the top 3 from each sector ranked according to stock performance with TOPSIS and GRA methods. The portfolios created based on the results obtained with TOPSIS and GRA methods and the performance comparison with other indicators are given in Table 13. The performances were determined based on one-year stock performances between 06.02.2020 - 05.02.2021 to serve as an example and give an idea. Therefore, when evaluating the results, the influx of new investors towards the stock market in the said period and excessive volatility should also be considered. Table 13 shows the portfolios' performances created with the three most successful companies from three sectors when the MV/BV and P/E ratios are operated normally (Case 1) and reverse (Case 2). These performances were also compared with BIST100 (XU100), industry indices and alternative investment instruments. Portfolio performances represent the average value of the price changes in the stocks of companies in each sector in the period of 06.02.2020-06.02.2021 in percentage terms. The portfolio's performance in the first case was realized as 48.09% and performed better than the XBANK, XU100 index, gold

and US Dollar. However, among the sector portfolios consisting of three companies, it only performed better than the XBANK. There are no significant differences in the reverse study of P/E and MV/BV ratios in the second case. From here, it can be concluded that the ratios mentioned above within and between sectors are close to each other.

**Table 13. Performances of High-Performance Company Portfolios and Other Alternatives**

| | First Case | | | Second Case | |
|---|---|---|---|---|---|
| **Companies** | **% Change** | **By sector (%)** | **Companies** | **% Change** | **By sector (%)** |
| ***Garanti BBVA*** | -18,46 | -19,32 (3 BANK) | ***Garanti BBVA*** | -18,46 | -19,32 (3 BANK) |
| ***Halkbank*** | -25,25 | | ***Halkbank*** | -25,25 | |
| ***Is Bankasi*** | -14,25 | | ***Is Bankasi*** | -14,25 | |
| ***BIM*** | 47,34 | 94,13 (3 TCRT) | ***BIM*** | 47,34 | 83,54 (3 TCRT) |
| ***Bizim*** | 44,78 | | ***Vakko*** | 13,01 | |
| ***Doğuş*** | 190,27 | | ***Doğuş*** | 190,27 | |
| ***Bilici*** | 77,46 | 69,45 (3 TEKS) | ***Bilici*** | 77,46 | 71,73 (3 TEKS) |
| ***Kordsa*** | 62,05 | | ***Kordsa*** | 62,05 | |
| ***Yataş*** | 68,83 | | ***Arsan*** | 75,67 | |
| ***Portfolio Average*** | ***48,09*** | | ***Portfolio Average*** | ***45,32*** | |
| ***XU100*** | 24,89 | | ***XU100*** | 24,89 | |
| ***XBANK (All)*** | 3,38 | | ***XBANK (All)*** | 3,38 | |
| ***XTCRT (All)*** | 128,24 | | ***XPERAKENDE (All)*** | 128,24 | |
| ***XTEKS (All)*** | 128,17 | | ***XTEKSTIL (All)*** | 128,17 | |
| ***Gr Gold/₺*** | 36,44 | | ***Gr Gold/₺*** | 36,44 | |
| ***$/₺*** | 17,96 | | ***$/₺*** | 17,96 | |

The companies with the lowest stock market performance were determined in the study, and a second comparative portfolio success analysis was conducted. According to the results in Table 14, the higher returns are obtained from the companies' portfolio returns with the best performance given above in both cases. While the return was 82.39% in the first case, it was realized at a slightly higher rate of 45.41% in the second case, being relatively close to the above result.

**Table 14. Performance of Lowest Performance Company Portfolios**

| | First Case | | Second Case |
|---|---|---|---|
| **Companies** | **% Change (Return)** | **Companies** | **% Change (Return)** |
| Sekerbank | 25,30 | ICBCT | 32,74 |
| TSKB | 33,09 | QNB Finans | 36,97 |
| Yapı Kredi | -6,75 | Sekerbank | 25,30 |
| Adese | 85,39 | Migros | 72,99 |
| Migros | 72,99 | Metro | 33,48 |
| Teknosa | 76,67 | Bizim | 44,78 |
| Menderes | 129,33 | Yunsa | 7,00 |
| DAGİ | 193,33 | Derimod | 23,27 |
| Söktaş | 132,20 | Söktaş | 132,20 |
| **Mean** | **82,39** | **Mean** | **45,41** |

Here, companies with the lowest performance in the stock market expressed based on the rankings determined as a result of TOPSIS and Grey Relational Analysis methods; in the first case, P/E, MV/BV, Trading Volume, ROE, Dividend Yield, EPS variables are the companies with the lowest value and the highest BETA value. In the second case, companies with the highest P/E, MV/BV ratios, and BETA. These results can be interpreted as valid for P/E, MV/BV and neglected company anomalies (represented by trading volume), demonstrated in previous studies in the literature. The returns of portfolios with higher ratios were lower than those of portfolios with lower ratios. It is also concluded that portfolios created from companies that performed poorly in the previous five years displayed a higher performance during the pandemic period.

## 5. Conclusion and Discussion

In this study, a different approach has been tried to create a portfolio from stocks using multi-criteria decision-making techniques. TOPSIS and Grey relational analysis methods were used for this purpose. TOPSIS is one of the techniques used to manage real-life problems. According to this method, the best alternative is closest to the positive ideal solution and the furthest to the negative ideal solution. On the other hand, Grey relational analysis is one method used to analyze the uncertainties in multi-criteria decision problems. It offers a more straightforward solution than mathematical analysis methods in cases of uncertainty. Unlike the studies on the subject in the literature, the focus of this study was on stock market performance ratios. These methods were used to identify and rank the best alternatives (stocks) that can be preferred in portfolio creation. In this study, portfolios were formed by determining the companies with the highest and lowest performance according to financial ratios. Then, the performances of the portfolios created during the pandemic period were examined. As a result, in terms of stock market performance ratios, the companies' portfolio with the lowest performance reflected the highest average

percentage change. Moreover, the portfolios' returns were higher than the yields of XU100, XBANK, Gr Gold and US Dollar alternatives in the same period. This indicates that TOPSIS and GRA methods can be used as an alternative method in creating profitable portfolios.

The study also found evidence that MV/BV, P/E and neglected company anomalies are valid. The performance of portfolios formed in high indicators was higher than the performance of portfolios formed when they were low. This finding is compatible with the findings of many studies mentioned in the literature section of the study.

In future studies, more comprehensive analyzes can be carried out by expanding the number of stocks and sectors in the portfolio. In addition, analyzes can be extended in the context of different multi-criteria decision making methods. Again, it may be possible to examine the post-pandemic performances of portfolios created during the pandemic and market anomalies in this context.

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