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Enhancing Financial Performance Evaluation: The MEREC-RBNAR Hybrid Method for Sustainability-Indexed Companies

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ABSTRACT

Todays, companies are evaluated not only based on their financial activities but also in terms of their attitudes towards environmental, social, and governance (ESG) activities. In this context, companies are indexed based on their sustainability levels, striving to improve both their sustainability and financial levels simultaneously. The main objective of this research is to evaluate and compare the financial performance of companies listed in the sustainability index. To determine the financial performance of companies in the sustainability index, this research develops and proposes the MEREC (Method Based on the Removal Effects of Criteria) - RBNAR (Reference-Based Normalization Alternative Ranking) hybrid method. Additionally, financial ratios are used as criteria for evaluating companies' financial performance. The weights of financial ratios are calculated using the MEREC method, while the RBNAR method determines companies' financial performances. The application of the MEREC-RBNAR hybrid method is presented through a case study aiming to identify the financial performance of companies listed in the Istanbul Stock Exchange's sustainability index for the year 2022. Furthermore, in this research, companies' financial performance levels are determined by considering the averages of financial ratios of companies listed in the sustainability index, using reference-based normalization processes. The research concludes that the most critical criterion in determining the financial performance of companies in the sustainability index is Return on Equity (ROE). MAVI Clothing Industry and Trade Inc. is identified as the company with the highest financial performance level.

1. Introduction

Sustainability is defined as the process of economic development, environmental preservation, and ensuring social justice, along with their management. Sustainability has also become a way for companies to maintain their competitive edge by seeking sustainable practices in other markets or innovating within existing ones [1]. The economic and social dynamics of the 21st century have led

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to the central role of sustainability in the business world and financial analyses [2]. Issues such as global warming, resource depletion, and social inequality have made it imperative for companies to focus not only on their economic performance but also on environmental, social, and governance (ESG) parameters [3-4]. ESG performance has become a critical factor in the decisions of modern investors and stakeholders, directly impacting the long-term success and reputation of companies [5].

Sustainability has evolved from being merely a corporate social responsibility issue to becoming an integral part of strategic business decisions in today's world [6-7]. By adhering to sustainability principles, companies not only gain a competitive advantage but also contribute positively to society and the environment. In this context, a sustainability index is a measure used to evaluate the ESG performance of companies. These indexes consider various factors when assessing companies' sustainability practices, including environmental factors (*such as: carbon footprint, energy consumption, water usage*), social factors (*such as: labor rights, occupational health and safety, community relations*), and governance factors (*such as: ethical standards, corporate governance practices, transparency*) [8].

ESG performance of companies provides investors and stakeholders with comprehensive information about sustainability performance. Sustainability indexes help identify and compare companies that adhere to sustainability principles and excel in this area. This enables investors to make more informed decisions about investing in companies that align with their sustainability goals. Additionally, it encourages companies to act responsibly towards the environment and society, thereby enhancing their long-term success and reputation [9].

These indexes support sustainable investments by increasing transparency and accountability while boosting companies' competitive advantage. In this context, the BIST (Istanbul Stock Exchange) Sustainability 25 Index serves as a significant indicator, bringing together companies operating in Turkey according to sustainability principles and adopting best practices in this field. This index, which started being published on November 21, 2022, represents a significant step towards sustainability [4]. This index provides investors and other stakeholders with the opportunity to recognize and evaluate companies that are pioneers in sustainability [10]. The companies included in the *BIST Sustainability 25 Index* stand out for their environmental responsibilities, social awareness, and strong governance structures, while also distinguishing themselves with their financial performance [11].

Understanding financial performance plays a critical role in assessing a company's current situation and in determining its future growth potential. It is one of the fundamental determinants for a company's long-term success. Accurately evaluating companies' financial performance helps establish trust among investors and stakeholders. Understanding financial performance enables the identification of potential risks beforehand and the development of suitable risk management strategies. This increases the likelihood of the company achieving long-term success. Through financial analysis, companies obtain critical indicators in key areas such as liquidity, profitability, debt-paying capacity, asset efficiency, and growth potential by objectively examining their revenues, expenses, assets, and liabilities.

The primary motivation of this study is to propose and demonstrate the applicability of an MCDM (Multi-Criteria Decision Making) method aimed at determining the financial performance of companies with high levels of sustainability. In this context, the study conducts a financial performance analysis by considering financial ratios and applying it to companies listed in the Sustainability 25 Index of the Istanbul Stock Exchange. Additionally, the study aims to rank the financial performance of these companies.

The decision model of the study includes financial ratios as criteria and the companies in the sustainability index as alternatives. To solve the decision model, the MEREC (Method Based on the Removal Effects of Criteria) [12] - RBNAR (Reference-Based Normalization Alternative Ranking) hybrid method [13] is utilized. The MEREC method is employed to calculate the weights of the financial ratios in the decision-making process. The MEREC method is extended with the Z-Score normalization technique, as it considers the distances from reference values rather than using the traditional max-min criteria type. The Z-Score normalization technique aids in calculating normalization by considering reference values.

The RBNAR method is then used to calculate the financial performance of the companies. This method applies two different reference-based normalization processes: Z-Score normalization and Aytekin's reference-based normalization technique. By using the RBNAR method, the financial performances of the companies are calculated and ranked based on the distances of the financial ratios from their reference values. This approach ensures a comprehensive and robust assessment of the financial performance of the companies in the sustainability index.

1.1 Aims and contributions of the paper.

The primary aim of this study is to determine the financial performance of companies listed on the Istanbul Stock Exchange's sustainability index in Turkey. This research employs the MEREC-RBNAR hybrid method to conduct a comprehensive financial performance analysis. The specific aims of the study are as follows:

- *To Utilize the MEREC-RBNAR Hybrid Method:* Implement the method to calculate the significance levels of financial ratios, leveraging the Z-score normalization technique for normalization considering reference values. Apply the RBNAR method to identify and rank the financial performance levels of companies in the sustainability index, utilizing a two-step reference-based normalization technique.
- *To Analyze Financial Performance Using Key Financial Ratios:* Evaluate financial performance using the following financial ratios: Current ratio, return on equity, return on assets, operating profit margin, profit before tax margin, net profit margin, accounts receivables turnover, debt ratio.
- *To Determine and Rank Financial Performance Levels:* Identify and rank the financial performance of twenty companies included in the sustainability index. Determine the most significant financial ratio affecting financial performance, which is found to be Return on Equity.
- *To Identify the Top Performing Company:* Recognize MAVI as the company with the highest financial performance in the sustainability index.
- *To Conduct Sensitivity Analyses:* Perform sensitivity analyses to ensure the robustness of the MEREC-RBNAR method and validate the case study results.

This study makes several significant contributions to the field of financial performance analysis, particularly concerning companies listed on the Istanbul Stock Exchange's sustainability index. The key contributions are as follows:

- *Development and Application of a Hybrid Method:* This study introduces and applies the MEREC-RBNAR hybrid method, combining the MEREC and the RBNAR methods. This hybrid approach enhances the accuracy and reliability of financial performance analysis by incorporating both the significance of financial ratios and reference-based normalization techniques.
- *Comprehensive Financial Performance Analysis:* Utilizing key financial ratios, the study provides a detailed evaluation of financial performance. This multifaceted approach ensures a holistic assessment of companies' financial health and performance.

- *Normalization Techniques:* The study refines the MEREC method by incorporating the Z-score normalization technique, allowing for normalization based on reference values. This advancement improves the standardization process and ensures that the significant levels of financial ratios are accurately determined. The RBNAR method's two-step reference-based normalization technique is utilized, which considers distances from reference values, thus enhancing the normalization process's precision and effectiveness.
- *Robustness and Validation:* Sensitivity analyses are conducted to validate the MEREC-RBNAR method and the case study results. These analyses confirm the robustness of the method, ensuring that the findings are reliable and can be confidently used for decision-making purposes.

1.2 Organization of the paper

This paper is organized into six main sections. In Section 1, the research aims and motivations are presented. Section 2 provides a literature review, compiling studies focused on financial performance analysis using financial ratios. Section 3 explains the MEREC-RBNAR Hybrid Method and outlines the research methodology. In Section 4, the financial performance analysis of companies listed in the Istanbul Stock Exchange Sustainability Index is presented as a case study. Section 5 discusses the research results, supported by sensitivity analyses. Finally, Section 6 represents the conclusion.

2. Literature Review

In the literature, MCDM methods are frequently used to determine the financial performance of companies. Financial ratios are also employed as performance evaluation parameters. These financial ratios provide information about companies' liquidity, market position, leverage, efficiency, profitability, and other financial conditions. Numerous studies in the literature combine MCDM methods with financial ratios to evaluate company performance. Lin and Chang [14] considered eighteen financial ratios as performance evaluation parameters to calculate the sustainability performance of twenty-five Taiwanese banks from 2012 to 2016. Their research employed DEMATEL (Decision Making Trial and Evaluation Laboratory), ANP (Analytic Network Process), and SAW (Simple Additive Weighting) methods. Laha and Biswas [15] applied the Entropy-CODAS (Combinative Distance-based Assessment) method to evaluate the performance of banks in India. Tey *et al.* [16] used the AHP (Analytic Hierarchy Process) method based on SVN (Single-valued neutrosophic set) to determine the financial performance of five petrochemical companies listed on the Kuala Lumpur Stock Exchange.

Anthony *et al.* [17] utilized the TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) and COPRAS (Complex Proportional Assessment) methods to assess the financial performance of seven chemical companies from 2010 to 2018. Suvvari *et al.* [18] calculated the financial performance of twenty-four life insurance companies from 2013 to 2016 using the GRA (Grey Relational Analysis) method. Rodrigues and Rodrigues [19] identified the financial performance of companies operating in the Sugarcane Energy industry using Cluster and Discriminant analysis.

Perçin and Aldalou [20] determined the financial performance of companies in the airline industry using the fuzzy AHP-TOPSIS method. Shaverdi *et al.* [21] assessed the financial performance of companies in the petrochemical industry using the Fuzzy AHP-TOPSIS method. Ozcalici & Bumin [22] evaluated the financial performance of banks in Turkey using the EDAS (Evaluation Based on Distance from Average Solution), MOORA (Multi-Objective Optimization by Ratio Analysis), OCRA (Operational Competitiveness Rating), and TOPSIS methods. Iç *et al.* [23] assessed the financial performance of banks in Turkey using the AHP-VIKOR method.

Ghosh and Bhattacharya [24] calculated the financial performance of companies operating in the hospitality and tourism industry using the MEREC (Method Based on the Removal Effects of Criteria) and Grey-based CoCoSo (Combined Compromise Solution) methods. Tavana *et al.* [25] identified the performance of pharmaceutical companies using the DEMATEL-Fuzzy ANP (Analytic Network Process) method. Makki and Alqahtani [26] assessed the financial performance of companies operating in the energy sector using the AHP-TOPSIS method, considering financial ratios. Isik *et al.* [27] calculated the financial performance of companies in the food and beverage industry using the DEMATEL-CRITIC (Criteria Importance Through Intercriteria Correlation), EDAS, WASPAS (Weighted Aggregated Sum Product Assessment), and TOPSIS methods. Kara *et al.* [13] identified the financial performance of technology companies using a reference-based CRITIC-CIMAS (Criteria Importance Assessment) and RBNAR (Reference-Based Normalization Alternative Ranking) hybrid method, incorporating SVN sets. The studies compiled from the literature review are presented in Table 1.

Table 1
Literature review for financial performance analysis with MCDM

Authors	Country	Sector	Years	Methods
Tavana *et al.* [25]	USA	Pharmaceutical	-	DEMATEL-Fuzzy ANP
Shaverdi *et al.* [21]	Iran	Petrochemical	2003–2013	Fuzzy AHP-TOPSIS
Perçin & Aldalou [20]	Turkey	Airline	2017	Fuzzy AHP-TOPSIS
Rodrigues & Rodrigues [19]	Brazil	Sugarcane Energy	2014-2016	Cluster and Discriminant analysis
Lin & Chang [14]	Taiwan	Banking	2012-2016	DEMATE- ANP- SAW
Laha & Biswas [15]	India	Banking	2012-2017	Entropy-CODAS
Tey *et al.* [16]	Malaysia	Petrochemical	2017	SVN-AHP
Anthony *et al.* [17]	Indian	Chemical	2010-2018	TOPSIS-COPRAS
Suvvari *et al.* [18]	India	Life Insurance	2013-2016	GRA
Ozcalici & Bumin [22]	Turkey	Banking	2018	EDAS-MOORA-OCRA-TOPSIS
Iç *et al.* [23]	Turkey	Banking	2012-2016	AHP- VIKOR
Ghosh & Bhattacharya [24]	India	Hospitality & tourism	2019-2021	MEREC-Grey based CoCoSo
Makki & Alqahtani [26]	Saudi	Energy	2019-2021	AHP-TOPSIS
Isik *et al.* [27]	Turkey	Food/Beverage	2021	DEMATEL-CRITIC-EDAS-WASPAS-TOPSIS
Kara *et al.* [13]	Turkey	Technology	2023	SVN-CIMAS-CRITIC-RBNAR

3. Methodology

This research employs the MEREC-RBNAR hybrid method for financial performance analysis, comprising two stages. In Stage 1, the MEREC method is utilized to calculate the weights of financial ratios, which involves six steps: firstly, computing the financial ratios of companies to form the initial decision matrix; secondly, normalizing the initial decision matrix using the Z-Score normalization technique; thirdly, calculating the overall performance matrix; fourthly, deriving the partial performance matrix; fifthly, determining the sum of absolute decision matrix; and sixthly, establishing the weights of financial ratios. In Stage 2, the RBNAR method is employed to rank companies based on their financial performance, comprising three steps: initially applying Z-score normalization and Aytekin's reference-based normalization techniques to obtain two normalized matrices, which are then aggregated using the Heron mean; subsequently creating a weighted decision matrix by considering the weights of the financial ratios; and finally determining and ranking

the financial performance of the companies. The methodological flow of the research is presented in Figure 1.

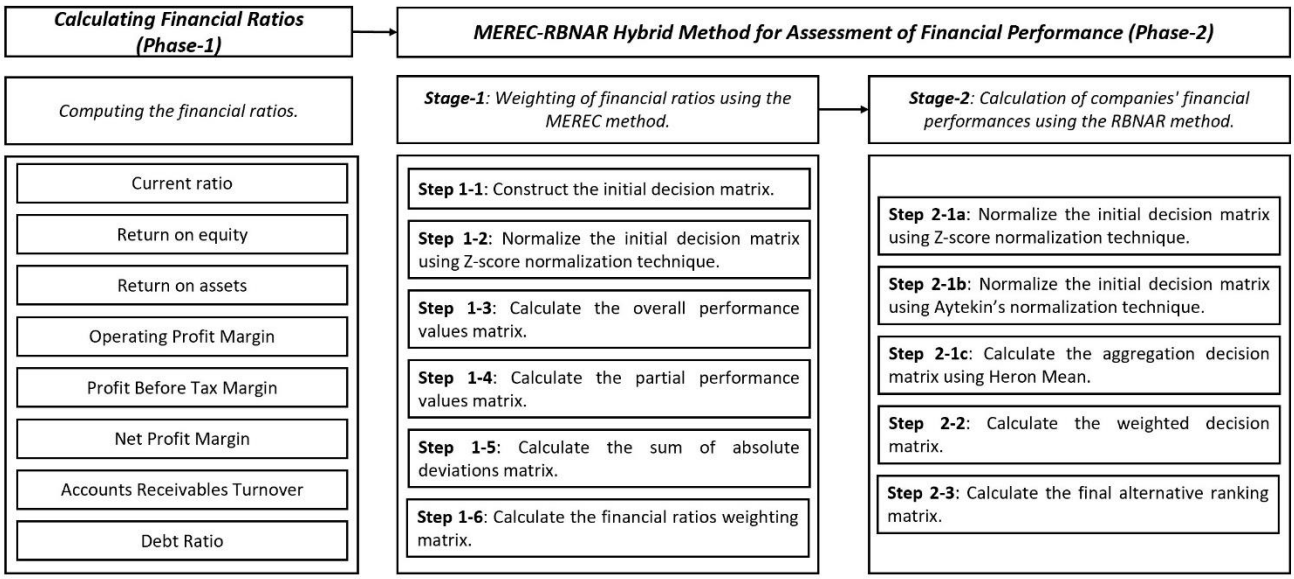

Fig. 1. Methodological framework

3.1 The MEREC-RBNAR Hybrid Method

In this research, a hybrid method combining MEREC-RBNAR is proposed for financial performance analysis. Within this hybrid method, the MEREC method is utilized to calculate the significance levels of financial ratios. The MEREC method is developed by considering the distances from reference values, and the Z-score normalization technique is applied as the normalization method. The RBNAR method is then used to compute the financial performances of companies. The notations for the MEREC-RBNAR hybrid method are as follows: A set of financial ratios $\mathcal{R} = \{\mathcal{R}_1, \mathcal{R}_2, \dots, \mathcal{R}_y, \dots, \mathcal{R}_\aleph\}$; $(y = 1,2, \dots, \aleph)$, a set of companies $\mathrm{C} = \{\mathrm{C}_1, \mathrm{C}_2, \dots, \mathrm{C}_x, \dots, \mathrm{C}_\mathcal{M}\}$; $(x = 1,2, \dots, \mathcal{M})$ and a set of reference values $\mathfrak{R} = \{\mathfrak{R}_1, \mathfrak{R}_2, \dots, \mathfrak{R}_y, \dots, \mathfrak{R}_n\}$; $(y = 1,2, \dots, \aleph)$. This hybrid method consists of two stages. The *first stage* involves weighing the financial ratios using the MEREC method. The *second stage* entails calculating the financial performances of companies using the RBNAR method. The procedural steps of the MEREC-RBNAR hybrid method are as follows.

First Stage: Weighting of financial ratios using the MEREC method.

Step 1-1: The initial decision matrix is constructed. This matrix displays the financial ratio values of the companies. The initial decision matrix $\left(A = \left[A_{xy}\right]_{\mathcal{M}\aleph}\right)$ is shown in Eq. (1).

$$A = \left[A_{xy}\right]_{\mathcal{M}\aleph} = \begin{bmatrix} A_{11} & \cdots & A_{1y} & \cdots & A_{1\aleph} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ A_{x1} & \cdots & A_{xy} & \dots & A_{x\aleph} \\ \vdots & \cdots & \vdots & \cdots & \vdots \\ A_{\mathcal{M}1} & \cdots & A_{\mathcal{M}y} & \dots & A_{\mathcal{M}\aleph} \end{bmatrix}; (x = 1,2, \dots, \mathcal{M}; y = 1,2, \dots, \aleph). \quad (1)$$

Step 1-2: The normalized decision matrix $\left(B = \left[B_{xy}\right]_{\mathcal{M}\aleph}\right)$ is calculated using the Z-score normalization technique [28]. The Z-score normalization calculation is shown in Eq. (2). In this

calculation, the reference value matrix $\left(\Re = \left[\Re_y\right]_{\aleph}\right)$ is used. The reference value matrix is determined based on the industry average in which the companies operate.

$$B_{xy} = e^{\left(\frac{\left(A_{xy}-\Re_y\right)^2}{-2\left(\sigma_y\right)^2}\right)}; (x = 1,2,\dots,\mathcal{M}; y = 1,2,\dots,\aleph). \quad (2)$$

herein, σ_y present the standard deviation of the y^{th} financial ratio.

Step 1-3: By employing Eq. (3), the overall performance values matrix $(D = [D_x]_{\mathcal{M}})$ of the companies are calculated.

$$D_x = ln\left(1 + \left(\frac{1}{\mathcal{M}}\sum_{y=1}^{\aleph}\left|ln\left(B_{xy}\right)\right|\right)\right); (x = 1,2,\dots,\mathcal{M}; y = 1,2,\dots,\aleph). \quad (3)$$

Step 1-4: By employing Eq. (4), the partial performance values matrix $\left(E = \left[E_{xy}\right]_{\mathcal{M}\aleph}\right)$ is computed.

$$E_{xy} = ln\left(1 + \left(\frac{1}{\mathcal{M}}\sum_{k,k\neq y}^{\aleph}\left|ln\left(B_{xy}\right)\right|\right)\right); (x = 1,2,\dots,\mathcal{M}; y = 1,2,\dots,\aleph). \quad (4)$$

Step 1-5: By employing Eq. (5), the sum of absolute deviations matrix $\left(F = \left[F_y\right]_{\aleph}\right)$ is calculated.

$$F_y = \sum_{x=1}^{\mathcal{M}}\left|E_{xy} - D_x\right|; (x = 1,2,\dots,\mathcal{M}; y = 1,2,\dots,\aleph). \quad (5)$$

Step 1-6: By employing Eq. (6), the financial ratios weighting matrix $\left(w = \left[w_y\right]_{\aleph}\right)$ is calculated.

$$w_y = \frac{F_y}{\sum_{y=1}^{\aleph} F_y}; (y = 1,2,\dots,\aleph). \quad (6)$$

Second Stage: Calculation of companies' financial performances using the RBNAR method.

The RBNAR method for calculating companies' financial performances relies on the use of Z-score normalization and Aytekin's reference-based normalization techniques [29]. The steps of the RBNAR method are as follows:

Step 2-1a: The first normalized decision matrix $\left(G = \left[G_{xy}\right]_{\mathcal{M}\aleph}\right)$ is obtained by applying the Z-score normalization technique shown in Eq. (7).

$$G_{xy} = e^{\left(\frac{\left(A_{xy}-\Re_y\right)^2}{-2\left(\sigma_y\right)^2}\right)}; (x = 1,2,\dots,\mathcal{M}; y = 1,2,\dots,\aleph). \quad (7)$$

herein, $\Re_y$ represents the reference value of the y^{th} financial ratio.

Step 2-1b: The second normalized decision matrix $\left(H = \left[H_{xy}\right]_{\mathcal{M}\aleph}\right)$ is obtained by applying the Aytekin's reference-based normalization technique shown in Eq. (8).

$$H_{xy} = 1 - \frac{\left|A_{xy}-\Re_y\right|}{\left|\Re_y\right|+10^{\beta}}; (x = 1,2,\dots,\mathcal{M}; y = 1,2,\dots,\aleph). \quad (8)$$

herein, $\Re_y$ represents the reference value of the y^{th} financial ratio and $\beta > 0$.

Step 2-1c: The aggregated normalized decision matrix $\left(I = \left[I_{xy}\right]_{\mathcal{M}\aleph}\right)$ is obtained by applying Heron Mean technique shown in Eq. (9).

$$I_{xy} = \mu\sqrt{H_{xy}I_{xy}} + (1-\mu)\frac{H_{xy}+I_{xy}}{2}; (x = 1,2,\dots,\mathcal{M}; y = 1,2,\dots,\aleph). \quad (9)$$

herein, $\mu \in [0,1]$.

Step 2-2: The weighted decision matrix $\left(K = \left[K_{xy}\right]_{\mathcal{M}\aleph}\right)$ is obtained by applying Eq. (10).

$$K_{xy} = w_y I_{xy}; (x = 1,2,\dots,\mathcal{M}; y = 1,2,\dots,\aleph). \quad (10)$$

Step 2-3: By employing Eq. (11), the final alternative ranking matrix $(L = [L_x]_{\mathcal{M}})$ is calculated.

$$L_{xy} = \sum_{y=1}^{\aleph} K_{xy} \, ; (x = 1,2, \dots, \mathcal{M}; y = 1,2, \dots, \aleph). \quad (11)$$

4. Case Study

A case study was developed to demonstrate the applicability of the MEREC-RBNAR hybrid method for calculating financial performance. The case study aims to determine the financial performance of companies listed on the Istanbul Stock Exchange and included in the sustainability index. The BIST Sustainability 25 index comprises the top 25 companies in Turkey in terms of sustainability. Five of these companies are in the banking sector. The remaining 20 companies operate in various other industries. Consequently, companies in the banking sector were excluded from the research scope because their financial performance is not comparable to that of companies in other sectors. Thus, the financial statements for 2022 of the twenty companies included in the BIST Sustainability 25 index were examined to gather data. Based on this data, the financial ratios for each company were calculated. Subsequently, an initial decision matrix was created. The companies and financial ratios included in the research are detailed in the following subsection.

4.1 Companies of Sustainability Index in Istanbul Stock Exchange and Financial Ratios

The codes and notations for the 20 companies included in the case study are presented in Table 2. These companies constitute the alternatives in the initial decision matrix. The goal is to determine and rank these companies' financial performance using the MEREC-RBNAR hybrid method.

Table 2
The companies included in the sustainability index.

	Code	Companies
C_1	AKCNS	AKÇANSA Cement Industry and Trade Inc.
C_2	ARCLK	ARÇELİK Inc.
C_3	BIMAS	BİM Birleşik Mağazalar Inc.
C_4	CIMSA	ÇİMSA Cement Industry and Trade Inc.
C_5	DOAS	DOĞUŞ Automotive Services and Trade Inc.
C_6	DOHOL	DOĞAN Companies Group Holding Inc.
C_7	ENJSA	ENERJISA Energy Inc.
C_8	ENKAI	ENKA Construction and Industry Inc.
C_9	KCHOL	KOÇ Holding Inc.
C_{10}	MAVI	MAVİ Clothing Industry and Trade Inc.
C_{11}	MGROS	MİGROS Trade Inc.
C_{12}	PETKM	PETKİM Petrochemical Holding Inc.
C_{13}	PGSUS	PEGASUS Air Transportation Inc.
C_{14}	SAHOL	HACI ÖMER SABANCI Holding Inc.
C_{15}	SISE	TÜRKİYE ŞİŞE VE CAM FABRİKALARI Inc.
C_{16}	TCELL	TURKCELL Communication Services Inc.
C_{17}	TKFEN	TEKFEN Holding Inc.
C_{18}	TOASO	TOFAŞ Turkish Automobile Factory Inc.
C_{19}	TTRAK	TÜRK TRAKTÖR VE ZİRAAT MAKİNELERİ Inc.
C_{20}	ZOREN	ZORLU ENERGY Electricity Generation Inc.

In the case study, eight financial ratios (*current ratio*, *return on equity*, *return on assets*, *operating profit margin*, *profit before tax margin*, *net profit margin*, *accounts receivables turnover*, *debt ratio*) are utilized to evaluate the financial performance of companies listed in the BIST Sustainability Index. These financial ratios provide insights into the companies' liquidity, profitability, efficiency, leverage,

and market performance. The financial ratios considered as criteria in the decision model are as follows:

Current ratio $(\mathcal{R}_1)$: The Current Ratio is a financial performance parameter that elucidates a company's ability to pay short-term liabilities using its assets. This parameter is calculated by dividing current assets by current liabilities. A high value of this parameter indicates that companies have a strong ability to meet their payment obligations. However, an excessively high Current Ratio may indicate deficiencies in companies' strategies for utilizing current assets, suggesting that these assets are not being utilized effectively. Therefore, the deviation of this parameter from the average Current Ratio of companies evaluating financial performance should be considered, aiming to determine the presence of optimal payment capacity. This parameter has been used as a criterion for evaluating financial performance in numerous studies [30-31] and is included in this research's decision model due to its reflection of a company's payment capacity.

Return on equity (ROE) $(\mathcal{R}_2)$: ROE is a financial parameter indicating a company's return on its equity. This parameter is calculated by dividing the company's net income by its equity. It serves as an indicator of profitability for investors. The high value of this parameter signifies that the company has a high level of profitability. However, it is essential to monitor this parameter for long-term profitability. Conversely, a very low ROE indicates that the company's profitability level is low, and its equity is not being utilized effectively. Therefore, like other studies, this parameter is included as a financial performance criterion in the decision model [32-33].

Return on assets (ROA) $(\mathcal{R}_3)$: ROA signifies the return a company generates by utilizing its assets. This parameter is calculated by dividing the company's net income for a period by its total assets. Essentially, ROA reflects the company's ability to utilize its assets effectively. A high ROA indicates that the company is deriving significant benefits from its assets. It is expected that the ROA value should be close to the industry average, indicating efficient asset utilization. If the ROA value is significantly lower than the industry average, it suggests that the company is not utilizing its assets effectively. This parameter is commonly used in financial performance analyses in the literature [25,34] and is evaluated as a criterion in the decision model in this research.

Operating Profit Margin $(\mathcal{R}_4)$: Operating Profit Margin" reflects companies' profitability levels over a specific period. This parameter is calculated by dividing operating income by net sales. A high value of this parameter indicates a high profit margin, while a low value suggests a lower level of profitability. Companies focus on achieving long-term profitability and operational efficiency by considering this financial indicator. It is essential to evaluate this parameter in comparison to industry averages. Therefore, this parameter is included in the research's decision model as a financial performance evaluation criterion [31-32].

Profit Before Tax Margin $(\mathcal{R}_5)$: This ratio indicates how much of a company's revenue is derived from its operations and reflects its pre-tax profitability. A high profit margin suggests strong profitability, whereas a low profit margin raises concerns about the company's profitability. Widely used to assess company performance, this financial indicator should also account for the impact of taxes in its analysis [35].

Net Profit Margin $(\mathcal{R}_6)$: This ratio measures the profitability of net sales after accounting for all expenses and taxes, showing the percentage of net income derived from net sales. It indicates how much of the net sales remains as net income after deducting all expenses and taxes [36].

Accounts receivables turnover $(\mathcal{R}_7)$: Accounts Receivables Turnover" indicates the level at which a company collects its receivables. This parameter is calculated by dividing a company's total sales for a period by its average receivables. A high value of this parameter indicates that companies collect their receivables at a rapid rate. However, an excessively high value of this parameter may indicate

a departure from providing long-term payment facilities to customers. Conversely, a very low value of this parameter indicates that companies are unable to collect receivables in a timely manner. Therefore, it is expected that this ratio should be close to industry averages. In this context, this parameter is considered in the determination process of companies' financial performance [13,37].

Debt ratio $(\mathcal{R}_8)$: The Debt Ratio indicates the extent to which a company's debts are used for investments in assets during a specific period. This parameter is calculated by dividing the total debts in a period by the total assets. A very high or very low Debt Ratio indicates issues in the company's borrowing policies. Therefore, this parameter should be close to industry averages. This parameter, which signifies a company's financial success, is considered a financial performance criterion [21,38].

4.2 Calculation of Financial Performances of the Companies using the MEREC-RBNAR Hybrid Method

To calculate and rank the financial performances of the companies in the Sustainability Index based on their financial performance levels, all steps of the MEREC-RBNAR Hybrid Method are applied sequentially. As a result of this application, the significant levels of financial ratios and the financial performances of the companies are determined. The application of the MEREC-RBNAR Hybrid Method is as follows:

First Stage: Weighting of financial ratios using the MEREC method.

Step 1-1: As shown in Eq. (1), the initial decision matrix $\left(A = \left[A_{xy}\right]_{\mathcal{M}\aleph}\right)$ was constructed by calculating the values of eight different financial ratios for twenty companies. The initial decision matrix is presented in Table 3.

Table 3
The initial decision matrix.

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_1	1.10510	0.41465	0.18862	7.31218	0.54511	12.96310	10.76005	17.08766
C_2	1.15911	0.17425	0.03572	4.64947	0.79503	6.78801	3.14976	3.52689
C_3	0.97519	0.32110	0.12613	27.22928	0.60718	6.44181	5.95664	5.52335
C_4	1.18989	0.58314	0.30712	6.19684	0.47334	15.13968	37.99953	41.50682
C_5	1.59334	0.67040	0.37977	21.54510	0.43351	16.94003	18.21443	16.77606
C_6	2.02295	0.29468	0.16400	13.24248	0.44344	15.17245	15.10367	15.09882
C_7	0.70361	0.67207	0.24495	14.99938	0.63553	9.88526	5.26545	17.16786
C_8	2.38631	0.01728	0.01318	12.97293	0.23706	19.81762	6.11524	3.42145
C_9	0.85723	0.47824	0.07470	14.80772	0.84380	16.55983	14.87342	13.10851
C_{10}	1.24637	0.53410	0.16883	16.74418	0.68390	19.09708	16.07911	13.77604
C_{11}	0.77367	0.63080	0.07083	224.00984	0.88772	3.65765	2.56134	3.46277
C_{12}	1.10279	0.34340	0.11973	9.93713	0.65133	6.96612	9.56651	13.38497
C_{13}	0.99796	0.39347	0.07411	56.51585	0.81165	22.64211	15.48936	16.61544
C_{14}	0.79903	0.41146	0.06612	43.17624	0.83929	42.11598	43.82116	35.13620
C_{15}	2.07213	0.21165	0.12281	6.56989	0.41976	18.26967	20.72589	21.11541
C_{16}	1.59975	0.35773	0.10914	9.73104	0.69491	36.51107	13.98728	20.51326
C_{17}	1.22504	0.32562	0.10713	8.80450	0.67098	7.66394	10.53707	11.24409
C_{18}	1.28062	0.75680	0.21206	5.93222	0.71979	13.62395	13.06306	13.06300
C_{19}	1.25623	0.81661	0.21535	12.97215	0.73628	13.82471	13.11421	13.60691
C_{20}	0.59862	0.00227	0.00059	6.08134	0.73885	17.93181	0.40038	0.13303

Step 1-2: Using Z-Score normalization technique (Eq. (2)), the normalized decision matrix $\left(B = \left[B_{xy}\right]_{\mathcal{M}\aleph}\right)$ was calculated and present Table 4. Herein, the reference value matrix $\left(\Re = \left[\Re_y\right]_{\aleph}\right)$ was used. This reference value matrix is shown in Table A.1 in the Appendix.

Table 4
The normalized decision matrix for MEREC method.

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_1	0.9564	0.9997	0.8824	0.9268	0.8480	0.9470	0.9602	0.9737
C_2	0.9830	0.5520	0.5614	0.9058	0.6757	0.6190	0.6126	0.5364
C_3	0.8493	0.9077	0.9898	0.9998	0.9778	0.5970	0.7661	0.6562
C_4	0.9928	0.7716	0.2276	0.9183	0.6105	0.9949	0.0818	0.0293
C_5	0.7677	0.5422	0.0475	0.9954	0.4716	0.9961	0.9212	0.9802
C_6	0.2650	0.8563	0.9700	0.9649	0.5055	0.9952	0.9932	0.9994
C_7	0.5209	0.5377	0.5579	0.9737	0.9989	0.8076	0.7296	0.9719
C_8	0.0571	0.2032	0.4259	0.9635	0.0598	0.9264	0.7743	0.5301
C_9	0.7148	0.9678	0.7974	0.9728	0.5042	0.9988	0.9954	0.9866
C_{10}	1.0000	0.8812	0.9570	0.9812	0.9724	0.9516	0.9787	0.9952
C_{11}	0.6096	0.6482	0.7756	0.0002	0.3614	0.4248	0.5796	0.5326
C_{12}	0.9550	0.9434	0.9784	0.9452	0.9989	0.6304	0.9247	0.9907
C_{13}	0.8718	0.9929	0.7941	0.8214	0.6171	0.7893	0.9884	0.9832
C_{14}	0.6419	0.9992	0.7484	0.9401	0.5198	0.0237	0.0212	0.1290
C_{15}	0.2227	0.6522	0.9844	0.9212	0.4260	0.9743	0.8160	0.8195
C_{16}	0.7602	0.9621	0.9506	0.9439	0.9558	0.0999	0.9999	0.8495
C_{17}	0.9989	0.9156	0.9442	0.9376	0.9871	0.6746	0.9543	0.9407
C_{18}	0.9975	0.3300	0.7595	0.9162	0.9053	0.9666	0.9974	0.9858
C_{19}	0.9998	0.2148	0.7402	0.9635	0.8632	0.9718	0.9977	0.9934
C_{20}	0.3951	0.1801	0.3565	0.9174	0.8561	0.9816	0.4610	0.3478

Step 1-3: Using Eq. (3), the overall performance values matrix ($D = [D_x]_{\mathcal{M}}$) of the companies was computed and presented in Table 5.

Table 5
The overall performance values matrix.

	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
D_x	0.0645	0.3429	0.1715	0.7156	0.4689	0.2472	0.2663	0.7615	0.1534	0.0360
	C_{11}	C_{12}	C_{13}	C_{14}	C_{15}	C_{16}	C_{17}	C_{18}	C_{19}	C_{20}
D_x	0.9457	0.0876	0.1527	0.8700	0.3461	0.3124	0.0868	0.1848	0.2292	0.5427

Step 1-4: Using Eq. (4), the partial performance values matrix $\left(E = \left[E_{xy}\right]_{\mathcal{M}\aleph}\right)$ was calculated and shown in Table 6.

Table 6
Partial performance values matrix.

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_1	0.9564	0.9997	0.8824	0.9268	0.8480	0.9470	0.9602	0.9737
C_2	0.9830	0.5520	0.5614	0.9058	0.6757	0.6190	0.6126	0.5364
C_3	0.8493	0.9077	0.9898	0.9998	0.9778	0.5970	0.7661	0.6562
C_4	0.9928	0.7716	0.2276	0.9183	0.6105	0.9949	0.0818	0.0293
C_5	0.7677	0.5422	0.0475	0.9954	0.4716	0.9961	0.9212	0.9802
C_6	0.2650	0.8563	0.9700	0.9649	0.5055	0.9952	0.9932	0.9994
C_7	0.5209	0.5377	0.5579	0.9737	0.9989	0.8076	0.7296	0.9719
C_8	0.0571	0.2032	0.4259	0.9635	0.0598	0.9264	0.7743	0.5301
C_9	0.7148	0.9678	0.7974	0.9728	0.5042	0.9988	0.9954	0.9866
C_{10}	1.0000	0.8812	0.9570	0.9812	0.9724	0.9516	0.9787	0.9952
C_{11}	0.6096	0.6482	0.7756	0.0002	0.3614	0.4248	0.5796	0.5326

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_{12}	0.9550	0.9434	0.9784	0.9452	0.9989	0.6304	0.9247	0.9907
C_{13}	0.8718	0.9929	0.7941	0.8214	0.6171	0.7893	0.9884	0.9832
C_{14}	0.6419	0.9992	0.7484	0.9401	0.5198	0.0237	0.0212	0.1290
C_{15}	0.2227	0.6522	0.9844	0.9212	0.4260	0.9743	0.8160	0.8195
C_{16}	0.7602	0.9621	0.9506	0.9439	0.9558	0.0999	0.9999	0.8495
C_{17}	0.9989	0.9156	0.9442	0.9376	0.9871	0.6746	0.9543	0.9407
C_{18}	0.9975	0.3300	0.7595	0.9162	0.9053	0.9666	0.9974	0.9858
C_{19}	0.9998	0.2148	0.7402	0.9635	0.8632	0.9718	0.9977	0.9934
C_{20}	0.3951	0.1801	0.3565	0.9174	0.8561	0.9816	0.4610	0.3478

Step 1-5: Using Eq. (5), the sum of absolute deviations matrix $\left(F = \left[F_y\right]_{\aleph}\right)$ was computed and represented in Table 7.

Table 7
The sum of absolute deviations matrix.

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_1	0.0052	0.0000	0.0148	0.0089	0.0195	0.0064	0.0048	0.0031
C_2	0.0015	0.0542	0.0526	0.0088	0.0354	0.0435	0.0444	0.0568
C_3	0.0174	0.0102	0.0011	0.0000	0.0024	0.0559	0.0285	0.0454
C_4	0.0004	0.0160	0.0948	0.0052	0.0306	0.0003	0.1660	0.2429
C_5	0.0209	0.0491	0.2723	0.0004	0.0606	0.0003	0.0064	0.0016
C_6	0.1388	0.0153	0.0030	0.0035	0.0689	0.0005	0.0007	0.0001
C_7	0.0645	0.0613	0.0575	0.0026	0.0001	0.0207	0.0307	0.0027
C_8	0.1829	0.0976	0.0511	0.0022	0.1796	0.0045	0.0150	0.0378
C_9	0.0367	0.0035	0.0246	0.0030	0.0763	0.0001	0.0005	0.0014
C_{10}	0.0000	0.0154	0.0053	0.0023	0.0034	0.0060	0.0026	0.0006
C_{11}	0.0243	0.0213	0.0124	0.5211	0.0507	0.0425	0.0268	0.0311
C_{12}	0.0053	0.0067	0.0025	0.0065	0.0001	0.0543	0.0090	0.0011
C_{13}	0.0148	0.0008	0.0250	0.0213	0.0532	0.0257	0.0013	0.0018
C_{14}	0.0235	0.0000	0.0153	0.0032	0.0349	0.2182	0.2255	0.1134
C_{15}	0.1425	0.0385	0.0014	0.0073	0.0784	0.0023	0.0181	0.0178
C_{16}	0.0254	0.0035	0.0046	0.0053	0.0041	0.2366	0.0000	0.0150
C_{17}	0.0001	0.0102	0.0066	0.0074	0.0015	0.0462	0.0054	0.0070
C_{18}	0.0003	0.1224	0.0290	0.0091	0.0104	0.0035	0.0003	0.0015
C_{19}	0.0000	0.1659	0.0304	0.0037	0.0147	0.0029	0.0002	0.0007
C_{20}	0.0698	0.1330	0.0779	0.0063	0.0113	0.0013	0.0579	0.0798

Step 1-6: Using Eq. (6), the financial ratios weighting matrix $\left(w = \left[w_y\right]_{\aleph}\right)$ was calculated and presented in Table 8.

Table 8
The financial ratios weighing matrix.

	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
w_y	0.1330	0.1417	0.1343	0.1079	0.1264	0.1325	0.1106	0.1136

Second Stage: Calculation of companies' financial performances using the RBNAR method.

Step 2-1a: Using Z-Score normalization technique (Eq. (7)), the first normalized decision matrix $\left(G = \left[G_{xy}\right]_{\mathcal{M}\aleph}\right)$ was calculated and shown in Table 9.

Table 9
The first normalized decision matrix for RBNAR method.

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_1	0.9564	0.9997	0.8824	0.9268	0.8480	0.9470	0.9602	0.9737
C_2	0.9830	0.5520	0.5614	0.9058	0.6757	0.6190	0.6126	0.5364
C_3	0.8493	0.9077	0.9898	0.9998	0.9778	0.5970	0.7661	0.6562
C_4	0.9928	0.7716	0.2276	0.9183	0.6105	0.9949	0.0818	0.0293
C_5	0.7677	0.5422	0.0475	0.9954	0.4716	0.9961	0.9212	0.9802
C_6	0.2650	0.8563	0.9700	0.9649	0.5055	0.9952	0.9932	0.9994
C_7	0.5209	0.5377	0.5579	0.9737	0.9989	0.8076	0.7296	0.9719
C_8	0.0571	0.2032	0.4259	0.9635	0.0598	0.9264	0.7743	0.5301
C_9	0.7148	0.9678	0.7974	0.9728	0.5042	0.9988	0.9954	0.9866
C_{10}	1.0000	0.8812	0.9570	0.9812	0.9724	0.9516	0.9787	0.9952
C_{11}	0.6096	0.6482	0.7756	0.0002	0.3614	0.4248	0.5796	0.5326
C_{12}	0.9550	0.9434	0.9784	0.9452	0.9989	0.6304	0.9247	0.9907
C_{13}	0.8718	0.9929	0.7941	0.8214	0.6171	0.7893	0.9884	0.9832
C_{14}	0.6419	0.9992	0.7484	0.9401	0.5198	0.0237	0.0212	0.1290
C_{15}	0.2227	0.6522	0.9844	0.9212	0.4260	0.9743	0.8160	0.8195
C_{16}	0.7602	0.9621	0.9506	0.9439	0.9558	0.0999	0.9999	0.8495
C_{17}	0.9989	0.9156	0.9442	0.9376	0.9871	0.6746	0.9543	0.9407
C_{18}	0.9975	0.3300	0.7595	0.9162	0.9053	0.9666	0.9974	0.9858
C_{19}	0.9998	0.2148	0.7402	0.9635	0.8632	0.9718	0.9977	0.9934
C_{20}	0.3951	0.1801	0.3565	0.9174	0.8561	0.9816	0.4610	0.3478

Step 2-1b: Using Aytekin's reference-based normalization technique (Eq. (8)), the second normalized decision matrix $\left(H = \left[H_{xy}\right]_{\mathcal{MN}}\right)$ was computed and presented in Table 10 ($\beta = 4$).

Table 10
The second normalized decision matrix for RBNAR method.

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_1	0.9999858	0.9999994	0.9999951	0.9981190	0.9999902	0.9996868	0.9996925	0.9997679
C_2	0.9999912	0.9999754	0.9999896	0.9978534	0.9999848	0.9990702	0.9989325	0.9988780
C_3	0.9999728	0.9999901	0.9999986	0.9998945	0.9999964	0.9990357	0.9992128	0.9990774
C_4	0.9999943	0.9999837	0.9999833	0.9980077	0.9999830	0.9999041	0.9975873	0.9973296
C_5	0.9999654	0.9999750	0.9999760	0.9995386	0.9999790	0.9999162	0.9995631	0.9997990
C_6	0.9999224	0.9999874	0.9999976	0.9987105	0.9999800	0.9999073	0.9998737	0.9999665
C_7	0.9999456	0.9999748	0.9999895	0.9988857	0.9999992	0.9993795	0.9991438	0.9997599
C_8	0.9998861	0.9999597	0.9999873	0.9986836	0.9999594	0.9996289	0.9992287	0.9988675
C_9	0.9999610	0.9999942	0.9999935	0.9988666	0.9999800	0.9999541	0.9998967	0.9998348
C_{10}	0.9999999	0.9999886	0.9999971	0.9990597	0.9999960	0.9997008	0.9997763	0.9999014
C_{11}	0.9999526	0.9999790	0.9999931	0.9802678	0.9999756	0.9987577	0.9988738	0.9988716
C_{12}	0.9999856	0.9999923	0.9999980	0.9983808	0.9999992	0.9990880	0.9995733	0.9998624
C_{13}	0.9999751	0.9999973	0.9999934	0.9969735	0.9999832	0.9993469	0.9998352	0.9998151
C_{14}	0.9999552	0.9999991	0.9999926	0.9983040	0.9999804	0.9974026	0.9970059	0.9979657
C_{15}	0.9999175	0.9999791	0.9999983	0.9980450	0.9999776	0.9997834	0.9993123	0.9993657
C_{16}	0.9999648	0.9999937	0.9999969	0.9983602	0.9999949	0.9979622	0.9999852	0.9994259
C_{17}	0.9999978	0.9999905	0.9999967	0.9982678	0.9999972	0.9991577	0.9996702	0.9996486
C_{18}	0.9999967	0.9999664	0.9999928	0.9979814	0.9999924	0.9997527	0.9999225	0.9998302
C_{19}	0.9999991	0.9999604	0.9999925	0.9986835	0.9999907	0.9997728	0.9999276	0.9998845
C_{20}	0.9999351	0.9999582	0.9999861	0.9979962	0.9999905	0.9998172	0.9986580	0.9985391

Step 2-1c: Using Heron Mean technique (Eq. (9)) [39], the aggregated normalized decision matrix $\left(I = \left[I_{xy}\right]_{\mathcal{M}\aleph}\right)$ was calculated and presented in Table 11 ($\mu = 0.5$).

Table 11
The aggregated normalized decision matrix for RBNAR method.

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_1	0.9780638	0.9998330	0.9402658	0.9621328	0.9224383	0.9731744	0.9798259	0.9866906
C_2	0.9914781	0.7594448	0.7650002	0.9512462	0.8299138	0.7977395	0.7940370	0.7497895
C_3	0.9230927	0.9532956	0.9948866	0.9998277	0.9888885	0.7851276	0.8787901	0.8186800
C_4	0.9963764	0.8820957	0.5454079	0.9577230	0.7933044	0.9974039	0.4127092	0.3422024
C_5	0.8799980	0.7536963	0.3707914	0.9974864	0.7112843	0.9980126	0.9599768	0.9899818
C_6	0.5736186	0.9267495	0.9849509	0.9817363	0.7318870	0.9975760	0.9965175	0.9997058
C_7	0.7410447	0.7510802	0.7629271	0.9862419	0.9994689	0.9009645	0.8591007	0.9857702
C_8	0.3836758	0.5261869	0.6827723	0.9809909	0.3872248	0.9626875	0.8831691	0.7460762
C_9	0.8514249	0.9838497	0.8958108	0.9857803	0.7310622	0.9993942	0.9976589	0.9931955
C_{10}	0.9999991	0.9396315	0.9783879	0.9901028	0.9861697	0.9754813	0.9892174	0.9975500
C_{11}	0.7927519	0.8145997	0.8842515	0.2526817	0.6408903	0.6815543	0.7750609	0.7475315
C_{12}	0.9773588	0.9715037	0.9891487	0.9716255	0.9994666	0.8041735	0.9617730	0.9952603
C_{13}	0.9348076	0.9964325	0.8940828	0.9070492	0.7970628	0.8912174	0.9941047	0.9915000
C_{14}	0.8110258	0.9996001	0.8696602	0.9689708	0.7404183	0.3321300	0.3272013	0.4611615
C_{15}	0.5416367	0.8168091	0.9921645	0.9592224	0.6828528	0.9870093	0.9053209	0.9072010
C_{16}	0.8759549	0.9809757	0.9751486	0.9709262	0.9777709	0.4323232	0.9999456	0.9229375
C_{17}	0.9994551	0.9573162	0.9718871	0.9676845	0.9935530	0.8289456	0.9768625	0.9699609
C_{18}	0.9987701	0.6197272	0.8756358	0.9566446	0.9520652	0.9831312	0.9986710	0.9928205
C_{19}	0.9999104	0.5354274	0.8652454	0.9809888	0.9303535	0.9857180	0.9988379	0.9966509
C_{20}	0.6630579	0.5071956	0.6376794	0.9572538	0.9266697	0.9907011	0.7041426	0.6312544

Step 2-2: Using Eq. (10), the weighted decision matrix $\left(K = \left[K_{xy}\right]_{\mathcal{M}\aleph}\right)$ was calculated and represented in Table 12. Herein, the financial ratios weighing matrix as shown in Table 8 were used.

Table 12
The weighted decision matrix for RBNAR method.

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_1	0.1300796	0.1416278	0.1263023	0.1037836	0.1166155	0.1289446	0.1083877	0.1121056
C_2	0.1318637	0.1075765	0.1027595	0.1026093	0.1049184	0.1056997	0.0878359	0.0851894
C_3	0.1227686	0.1350357	0.1336393	0.1078497	0.1250162	0.1040286	0.0972112	0.0930166
C_4	0.1325151	0.1249501	0.0732625	0.1033079	0.1002902	0.1321550	0.0456536	0.0388803
C_5	0.1170371	0.1067622	0.0498070	0.1075971	0.0899212	0.1322357	0.1061920	0.1124796
C_6	0.0762896	0.1312754	0.1323047	0.1058982	0.0925258	0.1321778	0.1102341	0.1135844
C_7	0.0985568	0.1063916	0.1024811	0.1063842	0.1263538	0.1193769	0.0950332	0.1120011
C_8	0.0510277	0.0745351	0.0917142	0.1058178	0.0489533	0.1275551	0.0976956	0.0847675
C_9	0.1132370	0.1393637	0.1203308	0.1063344	0.0924215	0.1324187	0.1103604	0.1128447
C_{10}	0.1329969	0.1331002	0.1314231	0.1068007	0.1246725	0.1292503	0.1094266	0.1133394
C_{11}	0.1054337	0.1153892	0.1187781	0.0272563	0.0810219	0.0903053	0.0857368	0.0849329
C_{12}	0.1299858	0.1376149	0.1328685	0.1048076	0.1263535	0.1065522	0.1063907	0.1130793
C_{13}	0.1243267	0.1411461	0.1200987	0.0978418	0.1007654	0.1180854	0.1099672	0.1126521
C_{14}	0.1078640	0.1415948	0.1168181	0.1045212	0.0936043	0.0440069	0.0361948	0.0523962
C_{15}	0.0720361	0.1157022	0.1332736	0.1034697	0.0863269	0.1307777	0.1001460	0.1030742
C_{16}	0.1164994	0.1389566	0.1309880	0.1047321	0.1236107	0.0572824	0.1106134	0.1048621
C_{17}	0.1329246	0.1356052	0.1305498	0.1043825	0.1256059	0.1098345	0.1080599	0.1102048
C_{18}	0.1328335	0.0877853	0.1176208	0.1031916	0.1203609	0.1302639	0.1104724	0.1128021

Companies	$\mathcal{R}_1$	$\mathcal{R}_2$	$\mathcal{R}_3$	$\mathcal{R}_4$	$\mathcal{R}_5$	$\mathcal{R}_6$	$\mathcal{R}_7$	$\mathcal{R}_8$
C_{19}	0.1329851	0.0758441	0.1162251	0.1058176	0.1176161	0.1306066	0.1104908	0.1132373
C_{20}	0.0881847	0.0718450	0.0856570	0.1032573	0.1171504	0.1312669	0.0778918	0.0717217

Step 2-3: Using Eq. (11), the final alternative ranking matrix $(L = [L_x]_{\mathcal{M}})$ for financial performance was calculated and shown in Table 13.

Table 13
The final alternative ranking matrix.

	AKCNS (C_1)	ARCLK (C_2)	BIMAS (C_3)	CIMSA (C_4)	DOAS (C_5)	DOHOL (C_6)	ENJSA (C_7)	ENKAI (C_8)	KCHOL (C_9)	MAVI (C_{10})
L_x	0.9678467	0.8284524	0.9185659	0.7510149	0.8220319	0.8942900	0.8665785	0.6820664	0.9273113	0.9810097
	MGROS (C_{11})	PETKM (C_{12})	PGSUS (C_{13})	SAHOL (C_{14})	SISE (C_{15})	TCELL (C_{16})	TKFEN (C_{17})	TOASO (C_{18})	TTRAK (C_{19})	ZOREN (C_{20})
L_x	0.7088542	0.9576525	0.9248834	0.6970003	0.8448064	0.8875447	0.9571672	0.9153304	0.9028227	0.7469749

5. Results and Implications

This research applies the MEREC-RBNAR hybrid method to determine the financial performance of companies. This hybrid method involves normalization steps that consider reference values based on max-min normalization. Using the Z-Score normalization technique developed within the MEREC method, the significant levels of financial ratios, which serve as indicators of financial performance, are determined for calculating companies' financial performances. RBNAR, on the other hand, ranks companies based on their financial performance by considering the expected reference values of financial ratios compared to other alternative ranking methods.

Two significant outcomes emerge from this research. The first important result is the significant level of financial ratios indicating the financial performance of companies in the sustainability index. The second significant result is the financial performance of companies included in the sustainability index.

The weights assigned to the financial ratios included in the decision model are as follows: "Return on equity $(\mathcal{R}_2)$ > Return on assets $(\mathcal{R}_3)$ > Current ratio $(\mathcal{R}_1)$ > Net Profit Margin $(\mathcal{R}_6)$ > Profit Before Tax Margin $(\mathcal{R}_5)$ > Debt ratio $(\mathcal{R}_8)$ > Accounts receivables turnover $(\mathcal{R}_7)$ > Operating Profit Margin $(\mathcal{R}_4)$ > ". According to this ranking, the most influential financial ratio in determining the financial performance of companies in the sustainability index is the Return on Equity ratio. Based on this outcome, companies should develop strategies aimed at increasing their Return on Equity ratios to improve their financial performance levels. By doing so, they can enhance their financial performance to a higher degree compared to other performance parameters in the financial performance levels.

The ranking of companies' financial performances in the decision model is as follows: " MAVI (C_{10}) > AKCNS (C_1) > PETKM (C_{12}) > TKFEN (C_{17}) > KCHOL (C_9) > PGSUS (C_{13}) > BIMAS (C_3) > TOASO (C_{18}) > TTRAK (C_{19}) > DOHOL (C_6) > TCELL (C_{16}) > ENJSA (C_7) > SISE (C_{15}) > ARCLK (C_2) > DOAS (C_5) > CIMSA (C_4) > ZOREN (C_{20}) > MGROS (C_{11}) > SAHOL (C_{14}) > ENKAI (C_8)". According to this ranking, the company with the best performance among those included in the sustainability index is MAVI. Following MAVI, the second-ranking company is AKCNS, and in third place is PETKM. The company with the lowest financial performance compared to the others is ENKAI. The financial performance scores of the companies are presented in Figure 2.

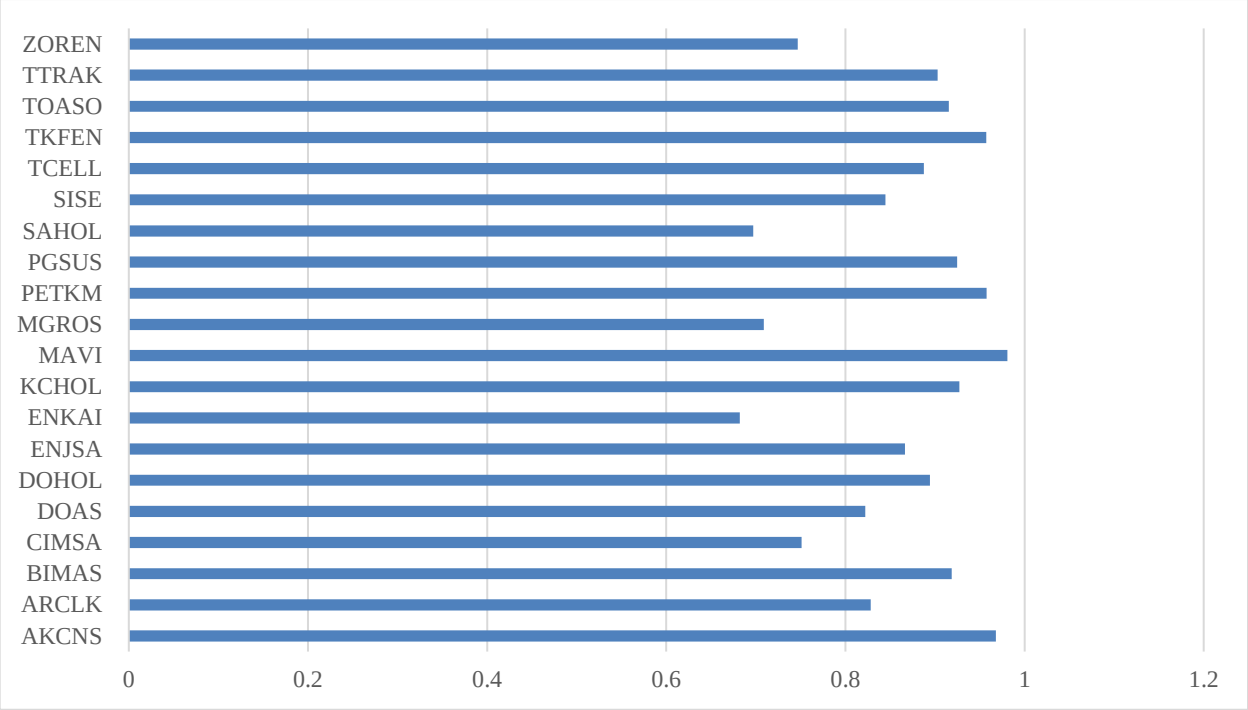

Fig. 2. Financial performance of the companies

5.1 Sensitivity Analysis

To test the robustness of the MEREC-RBNAR hybrid method, three different sensitivity analysis scenarios were developed:

- *Sensitivity Analysis Scenario-1:* Assuming equal weights for the financial ratios.
- *Sensitivity Analysis Scenario-2:* Excluding each financial ratio from the decision model one by one.
- *Sensitivity Analysis Scenario-3:* Assigning different values between 0 and 1 to the μ parameter, which denotes the significance of Z-score normalization and Aytekin's reference-based normalization techniques in determining the financial performance rankings.

The results obtained from these sensitivity analyses are as follows:

Sensitivity Analysis Scenario-1: After assuming equal importance for all criteria, the financial performance rankings of the companies were as follows: " MAVI (C_{10}) > AKCNS (C_1) > PETKM (C_{12}) > TKFEN (C_{17}) > KCHOL (C_9) > PGSUS (C_{13}) > TOASO (C_{18}) > BIMAS (C_3) > TTRAK (C_{19}) > DOHOL (C_6) > TCELL (C_{16}) > ENJSA (C_7) > SISE (C_{15}) > DOAS (C_5) > ARCLK (C_2) > ZOREN (C_{20}) > CIMSA (C_4) > MGROS (C_{11}) > ENKAI (C_8) > SAHOL (C_{14})". In this scenario, the overall ranking remained largely the same, but there were minor changes in the relative positions of some companies: BIMAS swapped with TOASO, ARCLK with DOAS, CIMSA with ZOREN, and SAHOL with ENKAI. These minor shifts indicate that the equal weighting assumption causes only minor changes, thus supporting the necessity of weighting criteria using the MEREC method.

Sensitivity Analysis Scenario-2: In this scenario, each financial ratio was excluded from the decision model one at a time, and the results were obtained. The rankings of the companies according to this scenario are presented in Table 14, and their financial performance scores are illustrated in Figure 3. Despite observing changes in the financial performance rankings, the company with the highest financial performance consistently remained MAVI across all sub-scenarios.

Table 14
Sensitivity Analysis Scenario-2.

Scenario	Rank	Best Company
Removed 1st criterion	$C_{10}> C_1> C_{12}> C_{17}> C_6> C_9> C_{13}> C_3> C_{18}> C_{16}> C_{15}> C_{19}> C_7> C_5> C_2> C_{20}> C_8> C_4> C_{11}> C_{14}$	MAVI
Removed 2nd criterion	$C_{10}> C_{18}> C_{19}> C_1> C_{17}> C_{12}> C_9> C_3> C_{13}> C_6> C_7> C_{16}> C_{15}> C_2> C_5> C_{20}> C_4> C_8> C_{11}> C_{14}$	MAVI
Removed 3rd criterion	$C_{10}> C_1> C_{17}> C_{12}> C_9> C_{13}> C_{18}> C_3> C_{19}> C_5> C_7> C_6> C_{16}> C_2> C_{15}> C_4> C_{20}> C_{11}> C_8> C_{14}$	MAVI
Removed 4th criterion	$C_{10}> C_1> C_{17}> C_{12}> C_{13}> C_9> C_{18}> C_3> C_{19}> C_6> C_{16}> C_7> C_{15}> C_2> C_5> C_{11}> C_4> C_{20}> C_{14}> C_8$	MAVI
Removed 5th criterion	$C_{10}> C_1> C_9> C_{17}> C_{12}> C_{13}> C_6> C_{18}> C_3> C_{19}> C_{16}> C_{15}> C_7> C_5> C_2> C_4> C_8> C_{20}> C_{11}> C_{14}$	MAVI
Removed 6th criterion	$C_{10}> C_{12}> C_{17}> C_1> C_{16}> C_3> C_{13}> C_9> C_{18}> C_{19}> C_6> C_7> C_2> C_{15}> C_5> C_{14}> C_{11}> C_{20}> C_4> C_8$	MAVI
Removed 7th criterion	$C_{10}> C_1> C_{12}> C_{17}> C_3> C_9> C_{13}> C_{18}> C_{19}> C_6> C_{16}> C_7> C_{15}> C_2> C_5> C_4> C_{20}> C_{14}> C_{11}> C_8$	MAVI
Removed 8th criterion	$C_{10}> C_1> C_{17}> C_{12}> C_3> C_9> C_{13}> C_{18}> C_{19}> C_{16}> C_6> C_7> C_{15}> C_2> C_5> C_4> C_{20}> C_{14}> C_{11}> C_8$	MAVI

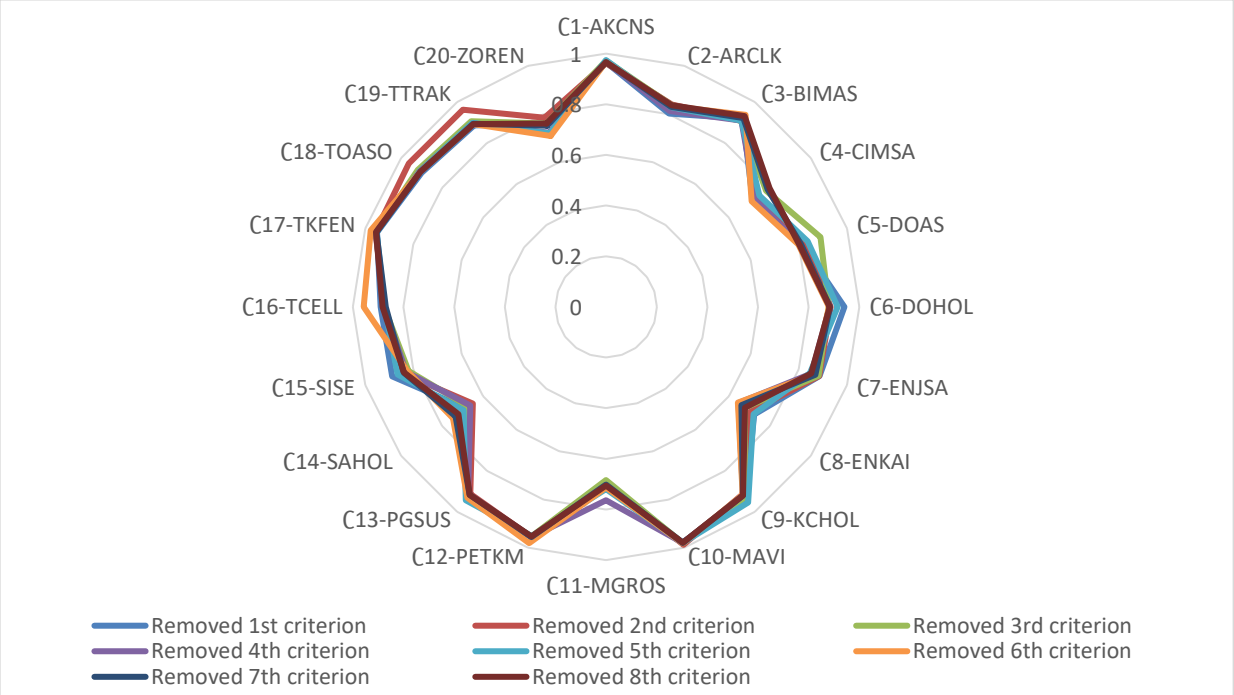

Fig. 3. Sensitivity analysis scenario-2 results

Sensitivity Analysis Scenario-3: In this scenario, different values ranging from 0 to 1 were assigned to the μ parameter, and the results were calculated accordingly. The results based on varying μ parameter values are shown in Figure 4. These results demonstrate that the financial performance rankings of the companies remained generally consistent, thereby supporting the robustness and reliability of the RBNAR method.

These sensitivity analyses collectively reinforce the robustness of the MEREC-RBNAR hybrid method and validate the stability of the case study results.

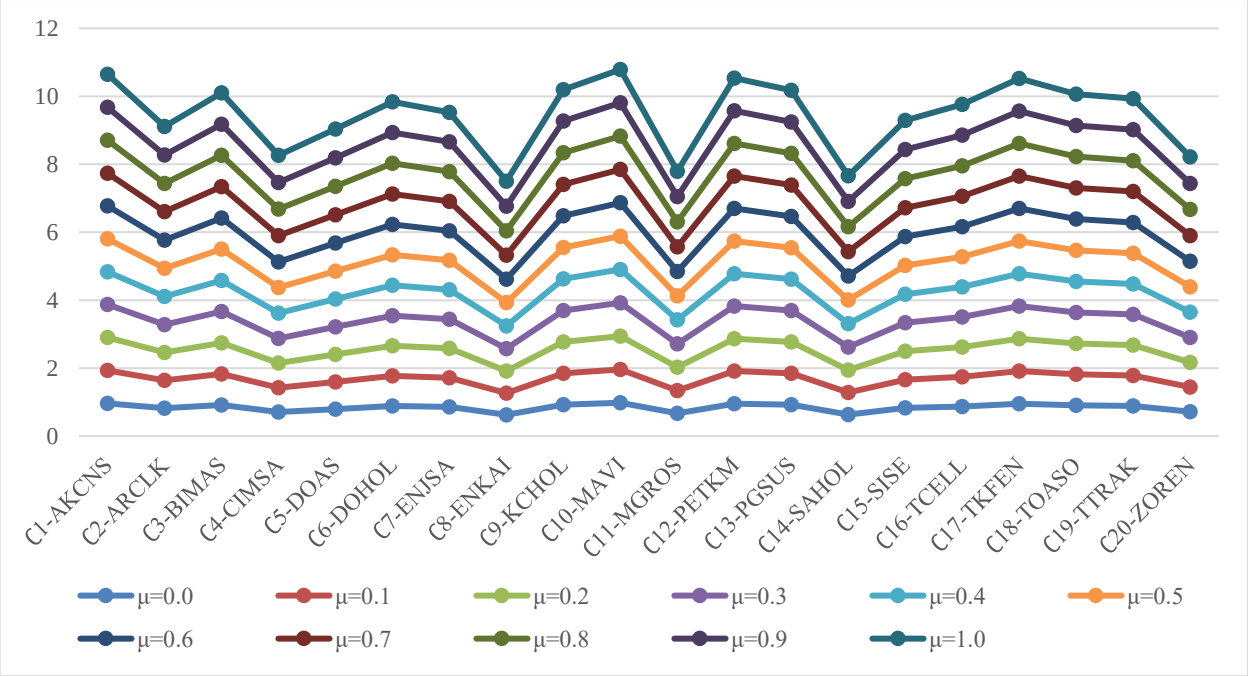

Fig. 4. Sensitivity analysis scenario-3 results

5.2 Research Implications

This study carries significant implications for the field of financial performance analysis, particularly within the context of companies listed on the Istanbul Stock Exchange's sustainability index. The research implications can be categorized as follows:

- *Methodological Advancements:* The introduction and application of the MEREC-RBNAR hybrid method represents a significant methodological advancement. By integrating the MEREC method with the RBNAR approach, the study offers a robust framework for financial performance analysis that leverages both the importance of financial ratios and reference-based normalization techniques.
- *Comprehensive Financial Performance Metrics:* The use of diverse financial ratios, including current ratio, return on equity, return on assets, operating profit margin, profit before tax margin, net profit margin, accounts receivables turnover, debt ratio, provides a thorough evaluation of companies' financial health. This comprehensive approach ensures that multiple dimensions of financial performance are considered, offering a holistic view of corporate financial stability and efficiency.
- *Benchmarking and Performance Ranking:* The ranking of companies within the sustainability index based on their financial performance offers practical benchmarking insights. Identifying MAVI as the top-performing company provides a benchmark for other firms to strive towards, while the ranking helps investors and stakeholders make informed decisions based on relative performance.
- *Practical Implications for Strategic Decision-Making:* The study's findings have practical implications for corporate strategic planning and decision-making. By understanding the critical financial ratios that drive performance, companies can develop targeted strategies to improve these metrics, thereby enhancing their financial health and competitive positioning within the sustainability index.

6. Conclusion

This research proposes and applies the MEREC-RBNAR hybrid method to assess the financial performance of companies listed in the sustainability index. This hybrid method involves calculations based on the distances to reference values for financial ratios in financial performance analysis. In this context, the MEREC method is expanded with Z-Score normalization, opening the way for its use in decision problems with reference values. The representation of financial performance calculation using the RBNAR method enriches the applicability of this approach. Sustainable companies demonstrate their level of environmental friendliness and eco-friendliness while conducting their activities. The BIST 25 Sustainability Index companies were chosen for this research because it aims to gain insights into their financial performance levels while carrying out sustainability practices. Thus, it enables a comparison of financial performance among companies with high sustainability levels.

The conducted case study using the MEREC-RBNAR hybrid method yielded two main results. The first is the weights of financial ratios, and the second is the ranking of companies' financial performance. These results shed light on two important points. Firstly, the reference-based criterion weighting method and financial performance ranking provide more realistic information compared to max-min normalization processes because reaching financial ratio reference values based on industry averages is the desired goal. The second important point is that Return on Equity is the most crucial ratio among financial ratios for companies listed in the sustainability index. This highlights the profitability level for investors and equity owners. Additionally, the company with the highest financial performance among those listed in the BIST 25 Sustainability Index is MAVI Clothing Industry and Trade Inc. Thus, it is concluded that this company is successful both in sustainability practices and financial decision processes. Ultimately, the primary emphasis of this research is to support the identification of financial performance based on reference values associated with successful sustainability activities for companies listed in this index.

Future research in this area could explore several avenues to enhance the understanding and application of financial performance analysis using methods like MEREC-RBNAR. Firstly, investigating the impact of additional financial ratios or performance indicators beyond those mentioned in this study could provide a more comprehensive view of companies' financial health and sustainability. This could include exploring ratios related to cash flow, asset turnover, or specific industry-related metrics.

Secondly, conducting comparative studies between different hybrid methods or traditional financial analysis techniques could offer insights into the strengths and weaknesses of each approach, helping researchers and practitioners make more informed decisions about which methods to use in different contexts.

Furthermore, examining the long-term effects of sustainable practices on financial performance could be a valuable area of research. This could involve longitudinal studies that track companies' financial performance metrics over several years to assess how sustainable initiatives impact profitability, shareholder value, and overall financial stability.

Additionally, exploring the applicability of MEREC-RBNAR and similar hybrid methods in different geographical regions or market segments could provide valuable insights into their cross-cultural or industry-specific effectiveness.

Lastly, integrating qualitative data, such as interviews with company stakeholders or expert opinions, alongside quantitative financial analysis could enrich the understanding of the relationship between sustainability practices and financial performance, offering a more holistic view of company performance.

Appendix

Table A.1

The reference value for financial ratios $\left(\Re = \left[\Re_y\right]_{\aleph}\right)$.

	$\Re_1$	$\Re_2$	$\Re_3$	$\Re_4$	$\Re_5$	$\Re_6$	$\Re_7$	$\Re_8$
$\Re_y$	1.25	0.42	0.14	26.17	0.64	16.10	13.84	14.76

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Conflicts of Interest

The authors declare no conflicts of interest.

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