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Evaluating Financial Performance of Companies in the Borsa Istanbul Sustainability Index Using the CRITIC-MABAC Method

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ABSTRACT

Companies need to monitor their financial performance and update their strategies to establish sustainable financial structures. Therefore, they analyze their financial performance using various analytical approaches. This study examines financial performance analysis using the MCDM (Multi-Criteria Decision-Making) approach to observe companies' financial performance and determine their performance levels relative to competitors within their respective indices. In this context, the CRITIC (Criteria Importance Through Intercriteria)-MABAC (Multi-Attributive Border Approximation Area Comparison) method is applied to financial performance analysis. The objective criteria weighting method, CRITIC, is used to prioritize financial performance criteria, while the MABAC method determines and ranks companies' financial performance. The study applies the CRITIC-MABAC method to assess the 2023 financial performance of the top ten companies listed in the Borsa Istanbul (BIST) Sustainability Index. The decision model includes twelve financial performance criteria. According to the findings, the most significant criterion is identified as the Cost of Goods Sold. Among the companies analyzed, Turkish Airlines Inc. (THYAO) is determined to have the highest financial performance. The robustness and consistency of the results are supported by sensitivity and comparative analyses. The study concludes with key insights and recommendations for future research.

1. Introduction

The United Nations has established 17 Sustainable Development Goals (SDGs) to foster global sustainable development by guiding national economies toward social, environmental, and economic progress. Within this framework, businesses play a pivotal role in achieving these objectives through sustainable practices and responsible governance. A key metric for evaluating corporate sustainability performance is the Environmental, Social, and Governance (ESG) score, which serves as an indicator of a company's commitment to sustainability [1]. In recent years, ESG rankings have gained increasing significance in investment decision-making across various industries [2]. The ESG

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rating system underscores the importance of strong ESG performance not only in assessing corporate sustainability but also in fostering long-term business growth and resilience. Consequently, improving ESG performance has become a strategic priority for businesses seeking to enhance their sustainability credentials [3]. Moreover, empirical evidence suggests that higher ESG performance is positively correlated with improved financial outcomes, reinforcing its critical role in corporate success [4].

Türkiye has made significant progress in advancing sustainability initiatives in recent years. Under the governance of Borsa İstanbul (BIST), the BIST Sustainability Index was first calculated and published on November 4, 2014 [5], with the aim of establishing a benchmark for companies listed on the exchange that demonstrate strong corporate sustainability performance. The primary objective of this index is to promote awareness and encourage the adoption of sustainability practices among Turkish businesses, particularly those publicly traded on Borsa İstanbul [6].

These developments highlight the critical role of financial studies in evaluating and improving sustainability-oriented policies, as well as in examining the intricate relationship between sustainability practices and financial performance. It is emphasized that businesses must engage in continuous financial performance assessments and enhancements to effectively achieve their sustainability goals. A sole environmental and social approach is insufficient; rather, financial evaluations are integral to strategic decision-making and serve as a key benchmark for companies striving to successfully meet SDGs [7].

Financial performance analysis relies on key financial indicators such as liquidity, profitability, cost of goods sold, net income, operational efficiency, leverage, market value, and cash flow. These indicators are derived from financial statements, including the income statement and balance sheet, which are generated through the accounting information system. Such metrics serve as essential tools for creditors, managers, and investors, enabling them to assess a company's financial strengths and weaknesses and make informed strategic decisions [8]. Moreover, a comprehensive evaluation of financial performance not only measures the effectiveness of current strategies but also provides critical insights into a company's long-term growth potential and sustainability [9].

In an era characterized by heightened competition, the emergence of innovative business models, and the rapid integration of digital technologies, the necessity for a rigorous assessment of corporate financial performance has become increasingly critical. Multi-Criteria Decision-Making (MCDM) methods serve as powerful analytical tools for conducting comprehensive financial evaluations. Within this framework, financial ratios play a pivotal role in comparing the performance of different organizations, serving as fundamental components of MCDM methodologies.

This study aims to conduct a financial performance analysis of companies listed on the Sustainability Index through the adoption of the MCDM approach, utilizing financial ratios. The primary motivation behind this research is to employ an objective criterion weighting method based on direct data to assess the financial performance of companies on the Sustainability Index and to rank them according to their financial performance using an alternative ranking method. In this context, the CRITIC (Criteria Importance Through Intercriteria) - MABAC (Multi-Attributive Border Approximation Area Comparison) method is employed for financial performance analysis. The CRITIC method [10] is used to calculate the importance levels of financial ratios, i.e., the criterion weights, while the MABAC method [11] is employed to identify and rank the financial performance of the companies. The CRITIC-MABAC method is applied to the top ten companies listed on the BIST Sustainability Index. Additionally, sensitivity and comparative analyses are performed to validate the robustness of the results.

This paper is structured into seven sections. Section 2 presents a literature review. Section 3 explains the CRITIC-MABAC methodology. Section 4 illustrates the application of the CRITIC-MABAC

method to assess the financial performance of the top ten companies listed on the BIST Sustainability Index. Section 5 discusses the results. Section 6 provides the implications for the findings. Finally, Section 7 concludes the paper.

2. Literature Review

The study of sustainability and performance analysis across various sectors has garnered significant attention in recent years, with numerous methodologies being applied to enhance decision-making processes in different industries. The literature review is presented in Table 1. This table provides a comprehensive summary of the methodologies employed in a range of studies published in 2024, alongside the specific sectors they focus on. The studies utilize a variety of MCDM methods to evaluate sustainability and performance across diverse industries.

Wu *et al.*, [12] explored the impact of COVID-19 on the airline industry using Dynamic Network Data Envelopment Analysis (DNDEA). The insurance sector, specifically non-life insurance, was studied by Isik *et al.*, [13] using methods such as PF-AHP and MAIRCA. Sharma and Kumar [14] utilized Entropy, TOPSIS, and VIKOR to analyze sustainability in the banking sector.

Liou *et al.*, [15] adopted DEMATEL and Interpretive Structural Modeling to investigate the aerospace sector, while Alsanousi *et al.*, [16] applied BWM and TOPSIS to analyze the Saudi Stock Market. Kaya *et al.*, [17] focused on the BIST Sustainability Index, using FUCOM, Copeland, and a combination of nine MCDM methods along with weight simulation. In the retail sector, Barutbaş *et al.*, [18] utilized DF TOPSIS and fuzzy sets for their analysis, and Kara *et al.*, [19] applied SVN-CIMAS-CRITIC-RBNAR for the technology sector within BIST.

In the BIST IT sector, Sezgin *et al.*, [20] employed MEREC and MARCOS to analyze sector performance. The Tehran Stock Exchange was analyzed by Ghaemi-Zadeh & Eghbali-Zarch [7] using a combination of methods including D-CRITIC, Fuzzy MULTI-MOORA, TOPSIS, MOOSRA, SAW, VIKOR, and PCA. Oubrahim and Sefiani [21] applied BWM and DEMATEL to the manufacturing sector, while Ergülen and Çalik [22] used F-BWM and MARCOS for the industrial sector in Türkiye. Lin *et al.*, [23] studied the shipping industry using a hybrid MCDM approach, combining Fuzzy-Delphi Method and DEMATEL.

The banking sector in emerging markets was analyzed by Hussain *et al.*, [24], employing AHP, TOPSIS, and GRA, while Shen [25] focused on Taiwan's blue-chip stocks using Fuzzy-Rough methods. Finally, Jiang *et al.*, [26] investigated the banking sector in Pakistan using ISM, DEMATEL. This diverse array of studies illustrates the extensive application of MCDM techniques across various industries, emphasizing the growing importance of these methodologies in improving sectoral efficiency, sustainability, and decision-making processes.

3. Methodology

The CRITIC-MABAC method is utilized in this study to assess the financial performance of companies. The implementation of this method requires specific input elements for the decision model, which include financial performance criteria, and the companies identified as alternatives. The methodology is applied in two main stages. In the first stage, the CRITIC method is used to determine the weights of the criteria through a structured five-step process. First, the initial decision matrix is constructed. Second, the matrix is normalized. Third, the relationship coefficient matrix is computed. Fourth, the information matrix is calculated. Finally, the criteria weight matrix is derived. The second stage involves the application of the MABAC method, which consists of seven steps. The process begins with constructing the initial decision matrix, followed by normalization. Next, the weighted decision matrix is computed by incorporating the criteria weights. The boundary proximity area matrix is then calculated, followed by the derivation of the distance matrix. Subsequently, the

ultimate distance matrix is computed. The final step determines the financial performance scores of the companies. The structural foundation of the CRITIC-MABAC methodology is illustrated in Figure 1. This section provides a detailed explanation of the methodology, outlining each step before proceeding to the application phase.

Table 1
 Literature review

Studies	Sector	MCMD Methods
Wu <i>et al.</i> , [12]	Airline Industry.	DNDEA.
Isik <i>et al.</i> , [13]	Insurance.	PF-AHP, MAIRCA.
Sharma & Kumar [14]	Banking.	Entropy, TOPSIS, VIKOR.
Liou <i>et al.</i> , [15]	Aerospace.	DEMATEL.
Alsanousi <i>et al.</i> , [16]	Saudi Stock Market.	BWM, TOPSIS.
Kaya <i>et al.</i> , [17]	BIST Sustainability Index	Nine MCDM methods.
Barutbaş <i>et al.</i> , [18]	Retail.	DF-TOPSIS.
Kara <i>et al.</i> , [19]	Technology.	SVN-CIMAS-CRITIC-RBNAR.
Sezgin <i>et al.</i> , [20]	BIST IT Sector	MEREC, MARCOS.
Ghaemi-Zadeh & Eghbali-Zarch [7]	Tehran Stock Exchange.	D-CRITIC, fuzzy MULTI-MOORA.
Oubrahim & Sefiani [21]	Manufacturing.	BWM, DEMATEL.
Ergülen & Çalik [22]	Industrial.	F-BWM, MARCOS.
Lin <i>et al.</i> , [23]	Shipping Industry.	Hybrid MCDM.
Hussain <i>et al.</i> , [24]	Banking Sector.	AHP, TOPSIS, GRA.
Shen [25]	Blue-Chip Stocks.	Fuzzy-Rough MCDM
Jiang <i>et al.</i> , [26]	Banking Sector.	ISM, DEMATEL.
Kara <i>et al.</i> , [27]	BIST Sustainability Index.	MEREC-RBNAR
Kara <i>et al.</i> , [28]	Transportation.	DEA
Kara <i>et al.</i> , [29]	Cosmetics.	WENSLO-ARLON
Kara <i>et al.</i> , [30]	Logistics.	MABAC
Kara <i>et al.</i> , [31]	Railway Transportation.	CRITIC-ROV
Kara <i>et al.</i> , [32]	Sustainability Index.	IVSF-RBNAR

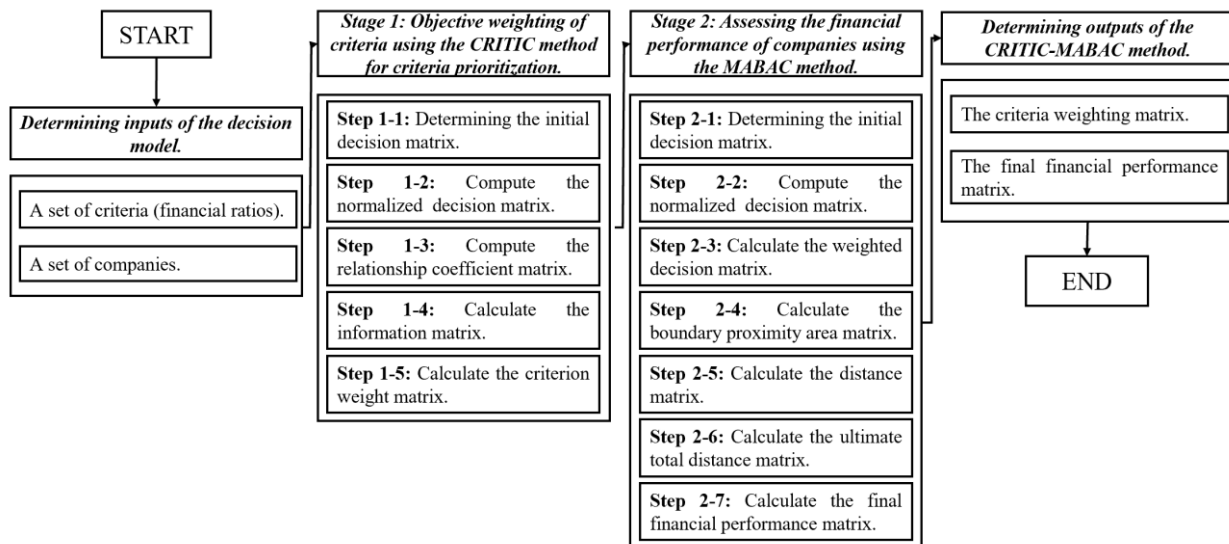


Fig. 1. The structural foundation of methodology

3.1 Pressure Distribution

In this study, the CRITIC-MABAC method is employed to assess the financial performance of companies. In the decision model, financial performance criteria are defined as evaluation factors, while companies are considered as alternatives. In this paper, the set of criteria is denoted as $\alpha =$

$\{\alpha_1, \alpha_2, \dots, \alpha_{\mathcal{F}}, \dots, \alpha_{\mathcal{F}}\}$ ($\mathcal{F} = 1, 2, \dots, \mathcal{F}$), and the companies are represented as $\beta = \{\beta_1, \beta_2, \dots, \beta_{\mathcal{L}}, \dots, \beta_{\mathcal{L}}\}$ ($\mathcal{L} = 1, 2, \dots, \mathcal{L}$). The notations used in the CRITIC-MABAC method are provided in the Appendix. The procedural steps of the CRITIC-MABAC method consist of two stages and several sub-steps. The steps of the method are as follows:

Stage 1: Objective weighting of criteria using the CRITIC method for criteria prioritization [10]:

Step 1-1: In the first step, an initial decision matrix ($\mathfrak{F} = [\mathfrak{F}_{\ell\mathcal{F}}]_{\mathcal{L}\mathcal{F}}$) is constructed, encompassing the data for each criterion corresponding to each alternative. Thus, the application steps of the CRITIC method for determining criterion weights are carried out based on this initial decision matrix.

Step 1-2: In the second step, the initial decision matrix undergoes a max-min normalization process. By applying the normalization procedure shown in Eq. (1), the normalized decision matrix ($\mathfrak{Z} = [\mathfrak{Z}_{\ell\mathcal{F}}]_{\mathcal{L}\mathcal{F}}$) is obtained.

$$\mathfrak{Z}_{\ell\mathcal{F}} = \begin{cases} \frac{\mathfrak{F}_{\ell\mathcal{F}} - \min_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}})}{\max_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}}) - \min_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}})} \text{ for } \mathcal{F} \in \alpha^+ \\ \frac{\max_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}}) - \mathfrak{F}_{\ell\mathcal{F}}}{\max_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}}) - \min_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}})} \text{ for } \mathcal{F} \in \alpha^- \end{cases}; (\ell = 1, 2, \dots, \mathcal{L}; \mathcal{F} = 1, 2, \dots, \mathcal{F}). \quad (1)$$

Step 1-3: In the third step, the correlation relationship among the criteria is calculated using Eq. (2). Consequently, the relationship coefficient matrix ($\mathfrak{C} = [\mathfrak{C}_{\mathcal{F}\mathcal{F}'}]_{\mathcal{F}\mathcal{F}}$) is obtained.

$$\mathfrak{C}_{\mathcal{F}\mathcal{F}'} = \begin{cases} \frac{\mathfrak{F}_{\ell\mathcal{F}} - \min_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}})}{\max_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}}) - \min_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}})} \text{ for } \mathcal{F} \in \alpha^+ \\ \frac{\max_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}}) - \mathfrak{F}_{\ell\mathcal{F}}}{\max_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}}) - \min_{1 \leq \dots < \mathcal{F} < \dots \leq \mathcal{F}}(\mathfrak{F}_{\ell\mathcal{F}})} \text{ for } \mathcal{F} \in \alpha^- \end{cases}; (\ell = 1, 2, \dots, \mathcal{L}; \mathcal{F} = 1, 2, \dots, \mathcal{F}). \quad (2)$$

Step 1-4: In the fourth step, the information value ($\mathfrak{Y}_{\mathcal{F}}$) for each criterion is calculated using Eq. (3). Consequently, the information matrix ($\mathfrak{Y} = [\mathfrak{Y}_{\mathcal{F}}]_{\mathcal{F}}$) is obtained.

$$\mathfrak{Y}_{\mathcal{F}} = \sigma_{\mathcal{F}} \sum_{\mathcal{F}'=1}^{\mathcal{F}} (1 - \mathfrak{C}_{\mathcal{F}\mathcal{F}'}); (\mathcal{F} = 1, 2, \dots, \mathcal{F}; \mathcal{F}' = 1, 2, \dots, \mathcal{F}). \quad (3)$$

herein, the $\sigma_{\mathcal{F}}$ value represents the standard deviation for each criterion.

Step 1-5: In the fifth step, a linear normalization process is applied using Eq. (4) to calculate the weight of each criterion. Consequently, the criterion weight matrix ($\mathfrak{w} = [\mathfrak{w}_{\mathcal{F}}]_{\mathcal{F}}$) is obtained. The criterion weights derived in this step are then used as criterion weights in the MABAC method.

$$\mathfrak{w}_{\mathcal{F}} = \frac{\mathfrak{Y}_{\mathcal{F}}}{\sum_{\mathcal{F}=1}^{\mathcal{F}} \mathfrak{Y}_{\mathcal{F}}}; (\mathcal{F} = 1, 2, \dots, \mathcal{F}). \quad (4)$$

Stage 2: Assessing the financial performance of companies using the MABAC method [11]:

Step 2-1: In the first step of the MABAC method for calculating and ranking financial performance values, the initial decision matrix used in the CRITIC method is also assigned as the initial decision matrix ($\mathfrak{F} = [\mathfrak{F}_{\ell\mathcal{F}}]_{\mathcal{L}\mathcal{F}}$) for the MABAC method.

Step 2-2: In the second step of the MABAC method, a max-min normalization process is applied, similar to the CRITIC method. The calculation in Eq. (1) is repeated to obtain the normalized decision matrix, resulting in the same normalized decision matrix ($\mathfrak{Z} = [\mathfrak{Z}_{\ell\mathcal{F}}]_{\mathcal{L}\mathcal{F}}$).

Step 2-3: In the third step of the MABAC method, the weighted decision matrix ($\mathfrak{X} = [\mathfrak{X}_{\ell\mathcal{F}}]_{\mathcal{L}\mathcal{F}}$) is obtained using Eq. (5). Here, the weight of each criterion ($\mathfrak{w}_{\mathcal{F}}$) is included in the calculation.

$$\mathfrak{X}_{\ell\mathcal{F}} = \mathfrak{w}_{\mathcal{F}} (\mathfrak{Z}_{\ell\mathcal{F}} + 1); (\ell = 1, 2, \dots, \mathcal{L}; \mathcal{F} = 1, 2, \dots, \mathcal{F}). \quad (5)$$

Step 2-4: In the fourth step of the MABAC method, the boundary proximity area matrix ($\mathfrak{D} = [\mathfrak{D}_{\ell\mathcal{F}}]$) is calculated using Eq. (6).

$$\mathfrak{D}_{\mathcal{F}} = \left(\prod_{\mathcal{F}=1}^{\mathcal{F}} \mathfrak{X}_{\ell\mathcal{F}} \right)^{1/\mathcal{F}}; (\ell = 1, 2, \dots, \mathcal{L}; \mathcal{F} = 1, 2, \dots, \mathcal{F}). \quad (6)$$

Step 2-5: In the fifth step of the MABAC method, the boundary proximity area distances for each alternative are calculated using Eq. (7). Consequently, the distance matrix ($\mathfrak{B} = [\mathfrak{B}_{\ell\mathcal{F}}]_{\mathcal{L}\mathcal{F}}$) is obtained.

$$\mathfrak{B}_{\ell\mathcal{F}} = \mathfrak{X}_{\ell\mathcal{F}} - \mathfrak{D}_{\mathcal{F}}; (\ell = 1, 2, \dots, \mathcal{L}; \mathcal{F} = 1, 2, \dots, \mathcal{F}). \quad (7)$$

Step 2-6: In the sixth step of the MABAC method, the ultimate total distance matrix ($\mathfrak{U} = [\mathfrak{U}_{\ell}]_{\mathcal{L}}$) is calculated using Eq. (8).

$$\mathfrak{U}_{\ell} = \sum_{\mathcal{F}=1}^{\mathcal{L}} \mathfrak{B}_{\ell\mathcal{F}}; (\ell = 1, 2, \dots, \mathcal{L}; \mathcal{F} = 1, 2, \dots, \mathcal{F}). \quad (8)$$

Step 2-7: In the seventh step of the MABAC method, by applying the linear normalization process in Eq. (9), the final financial performance matrix ($\mathfrak{R} = [\mathfrak{R}_{\ell}]_{\mathcal{L}}$) of the companies is obtained. In this matrix, the company with the highest value is determined to have the best financial performance, while the company with the lowest value is identified as having the lowest financial performance.

$$\mathfrak{R}_{\ell} = \frac{\mathfrak{U}_{\ell}}{\sum_{\ell=1}^{\mathcal{L}} \mathfrak{U}_{\ell}}; (\ell = 1, 2, \dots, \mathcal{L}). \quad (9)$$

The Algorithm showing the procedural steps of the CRITIC-MABAC method used for financial performance calculation and ranking is presented in Table 2.

4. Application

4.1 Definition of the financial performance criteria

In this application, 12 financial indicators (*Cost of Goods Sold, EBITDA Margin, ROA, Operating Income, Pretax Income, Net Income, Market Capitalization, Enterprise Value, Revenue, TOBIN Q, ROE, Operating Margin*) are utilized to evaluate the financial performance of companies listed in the BIST Sustainability Index. These financial indicators shed light on the companies' market performance, liquidity, profitability, efficiency, and leverage. The following financial indicators are considered as criteria in the choice model:

Cost of Goods Sold (α_1): It refers to the direct costs incurred in the production and supply processes of the goods/services sold by a business. These costs include expenditures such as raw material purchases, labor expenses, energy and materials used in the production processes, as well as the storage and transportation of product [33]. The cost of goods sold appears on a company's income statement and is a fundamental element in calculating gross profit. Gross profit is derived by subtracting the cost of goods sold from net sales, and this value reflects the difference between the revenue generated from product sales and the direct production costs, thus being used to determine the company's profitability [34]. The cost of goods sold is employed to analyze a company's efficiency and cost management. The high cost of goods sold indicates low profit margins and reveals inefficiencies in the company's cost structure. Accurate calculation and management of the cost of goods sold is critical for a business's cost efficiency and profitability analysis.

Earnings Before Interest, Tax, Depreciation and Amortization (EBITDA) Margin (α_2): It is defined as the ratio of a company's profit from its operations to its total revenue, serving as a critical financial indicator for evaluating operational efficiency. EBITDA, which stands for earnings before interest, taxes, depreciation, and amortization, excludes these costs to provide an effective measure for assessing a company's cash flow. This metric reflects how independent the company's core operations are from external costs [35]. The EBITDA margin is calculated by dividing EBITDA by total revenue and expressing it as a percentage. A high EBITDA margin indicates that the company can convert a large portion of its revenue into operational profit, demonstrating effective cost

management. In contrast, a low margin may suggest high operating costs or weak operational efficiency. This ratio is widely used by investors and analysts to assess a company's profitability performance and overall financial condition [36].

Return on Assets (ROA) (α_3): It is an important financial indicator that demonstrates how effectively a company utilizes its total assets to generate profit. This ratio is calculated by dividing the company's net profit by its total assets, reflecting the profitability associated with asset utilization. A high ROA indicates that the company is efficiently using its assets to generate substantial profit, thereby showing its operational efficiency and effectiveness, while a low ROA suggests that assets are being utilized less efficiently, or profitability is weak. ROA is commonly used to assess a company's financial performance, asset management, and profitability levels [37-39].

Table 2
 The algorithm of the CRITIC-MABAC method

Algorithm	<i>The main objective of this algorithm is to demonstrate the procedural steps of the CRITIC-MABAC method for financial performance calculation.</i>
Input	A set of financial performance criteria $\alpha = \{\alpha_1, \alpha_2, \dots, \alpha_f, \dots, \alpha_F\}$ ($f = 1, 2, \dots, F$). A set of companies $\beta = \{\beta_1, \beta_2, \dots, \beta_\ell, \dots, \beta_L\}$ ($\ell = 1, 2, \dots, L$).
Begin	
Stage 1	Objective weighting of criteria using the CRITIC method for criteria prioritization;
Step 1-1	Determine the initial decision matrix ($\mathfrak{X} = [\mathfrak{X}_{\ell f}]_{L \times F}$).
Step 1-2	Calculate the normalized decision matrix ($\mathfrak{Z} = [\mathfrak{Z}_{\ell f}]_{L \times F}$) using Eq. (1).
Step 1-3	Calculate the relationship coefficient matrix ($\mathfrak{C} = [\mathfrak{C}_{ff'}]_{F \times F}$) using Eq. (2).
Step 1-4	Calculate the information matrix ($\mathfrak{Y} = [\mathfrak{Y}_f]_F$) using Eq. (3).
Step 1-5	Determine the criterion weight matrix ($\varpi = [\varpi_f]_F$) using Eq. (4).
Stage 2	Assessing the financial performance of companies using the MABAC method;
Step 2-1	Determine the initial decision matrix ($\mathfrak{X} = [\mathfrak{X}_{\ell f}]_{L \times F}$).
Step 2-2	Calculate the normalized decision matrix ($\mathfrak{Z} = [\mathfrak{Z}_{\ell f}]_{L \times F}$) using Eq. (1).
Step 2-3	Calculate the weighted decision matrix ($\mathfrak{X} = [\mathfrak{X}_{\ell f}]_{L \times F}$) using Eq. (5).
Step 2-4	Calculate the boundary proximity area matrix ($\mathfrak{D} = [\mathfrak{D}_f]_F$) using Eq. (6).
Step 2-5	Calculate the distance matrix ($\mathfrak{B} = [\mathfrak{B}_{\ell f}]_{L \times F}$) using Eq. (7).
Step 2-6	Calculate the ultimate total distance matrix ($\mathfrak{U} = [\mathfrak{U}_\ell]_L$) using Eq. (8).
Step 2-7	Calculate the final financial performance matrix ($\mathfrak{R} = [\mathfrak{R}_\ell]_L$) using Eq. (9).
Output	The criteria weighting matrix ($\varpi = [\varpi_f]_F$), The final financial performance matrix ($\mathfrak{R} = [\mathfrak{R}_\ell]_L$).
End.	

Operating Income (α_4): It is a financial indicator that reflects the profit generated from a company's core activities. This figure is calculated by excluding non-operating expenses, such as interest expenses, taxes, and depreciation, from the company's net income [40]. Operating profit serves as an important financial indicator when evaluating a company's operational efficiency and profitability. This ratio reflects how profitable a company's core business activities are and how sustainable the business model is, independent of external factors. A high operating profit indicates strong efficiency and effectiveness in operational processes, while a low operating profit suggests high operational costs or revenues falling short of expectations [41].

Pretax Income (α_5): A financial metric known as pretax income shows how much money a business makes overall before taxes are subtracted. This amount is determined by deducting interest

costs, tax costs, and other associated expenses from the net profits of the business. Independent of the effects of taxes, pretax income is a crucial financial metric for evaluating the profitability and financial success of a business. Because it displays the profit from the company's core operations, untouched by financing costs and taxes, this ratio provides insight into the overall financial structure and operational effectiveness of the business. A company's financial situation is examined using pretax income, which is unaffected by possible tax liabilities and financial tactics [42-43].

Net Income (α_6): It represents the final profit a company retains after all revenues and expenses have been accounted for. This amount reflects the remaining profit after deducting all costs, taxes, interest expenses, depreciation, and other expenditures from the company's income. Net income is one of the most important indicators for evaluating a company's financial performance, as it indicates the result after the company has met all its financial obligations. A high net income suggests that the company is effectively managing its operations and generating profitability, while a low net income may indicate high costs or insufficient revenue growth. Net income is typically found on the income statement and is used by investors to analyze the company's financial health and profitability [44-45].

Market Capitalization (α_7): One important financial metric that establishes a company's overall worth is its market capitalization. The market value of the company's shares is multiplied by the total number of outstanding shares to arrive at this figure. This metric shows how a company's financial size and market value are determined. Market capitalization is frequently used to categorize a company's size and evaluate its prospects for future expansion. Market capitalization also shows how risky the company is. While businesses with smaller market capitalizations could be riskier, those with larger market capitalizations are generally thought to be more stable [46-48].

Enterprise Value (α_8): This is a comprehensive financial indicator that determines a company's total value, considering not only its market capitalization but also its debts and cash-like assets. Enterprise value is calculated by adding the company's total debt to its market capitalization and subtracting cash and cash equivalents. This value provides a more accurate reflection of the cost of acquiring a company in its entirety and is used by investors and analysts to evaluate the company's financial structure, value, and potential acquisition opportunities. Enterprise value considers the impact of debts and cash position, making it a more comprehensive valuation tool in financial analyses [49-50].

Revenue (α_9): One key financial metric is revenue, which shows how much money a business makes overall by selling goods or services. It is the revenue that comes directly from a business's operations. When assessing a company's economic size and financial success, revenue is a crucial financial metric [51]. It gives information about a company's market efficacy and customer demand and shows the overall value of its sales, minus taxes, costs, and expenses [52].

Tobin Q (α_{10}): Developed by economist James Tobin, Tobin's Q is a financial indicator that shows the ratio of a company's market worth to the cost of replacing its assets. An essential instrument for assessing a company's investment readiness is this ratio. Businesses are encouraged to make new investments when the market value of the assets exceeds the cost of replacing them, as shown by a Tobin Q ratio above 1. On the other hand, if Tobin Q is less than 1, the market value of the assets is less than their replacement cost, indicating that businesses should postpone or restrict future investments [53-55].

Return on Equity (ROE) (α_{11}): One important financial metric that assesses a company's profitability in relation to its equity is ROE. The company's net income is divided by the equity held by its shareholders to arrive at this ratio. It demonstrates how effectively a business uses its equity to turn a profit. A high ROE shows that the business is making good use of its equity to generate significant returns. On the other hand, a low ROE indicates that the business may not be making the

best use of its equity or that it is not very profitable. ROE is frequently used to assess the profitability of a business and forecast its prospects for future expansion [56-57].

Operating Margin (α_{12}): A key financial metric that establishes the proportion of a business's operational profit to its overall revenue is operating margin. This ratio evaluates a company's operational efficiency and profitability by calculating the profit it makes from sales after subtracting direct operating expenses. Usually, operating income is divided by total revenue to get operating margin. This ratio shows how well the business controls its expenses. A low operating margin might be a symptom of excessive running costs or lower-than-expected revenue, whereas a high operating margin indicates that the business turns a sizable amount of its revenue into profit and exhibits effective operational procedures [58].

4.2 Definition of the companies

In 2023, the top ten companies with the largest assets included in the BIST Sustainability Index were included in the study. These are as follows:

Koç Holding Inc. (KCHOL) (β_1): Established in 1926, Koç Holding is a multinational company and one of the biggest industrial enterprises in Türkiye. It works in several industries, such as retail, energy, automotive, financial services, and durable consumer products. Arçelik, Tofaş, Aygaz, and Yapı Kredi are some of its well-known brands. Koç Holding prioritizes corporate social responsibility and sustainability to increase its market share in both home and foreign markets [59].

Turkish Petroleum Refineries Corp. (TUPRS) (β_2): Established in 1983, TUPRS is Türkiye's largest oil refinery. The company specializes in processing crude oil and converting it into various petroleum products. It meets a significant portion of Türkiye's fuel demand. With refineries in Istanbul and İzmit, TUPRS produces products such as gasoline, diesel, jet fuel, and LPG. By investing in environmentally friendly production technologies and energy efficiency projects, the company has taken significant steps in sustainability. TUPRS has established a strong position in the local market while also maintaining a competitive presence in global markets [60].

Turkish Airlines Inc. (THYAO) (β_3): Founded in 1933, Turkish Airlines is Türkiye's largest airline. Operating flights to over 300 destinations worldwide, Turkish Airlines holds a significant position in the industry with its modern fleet and extensive network. The company offers high-quality service on both domestic and international flights and is a member of the Star Alliance, engaging in global airline partnerships. Additionally, Turkish Airlines makes substantial investments in sustainability and eco-friendly operations, aiming to enhance its competitive strength in the industry through digitalization and innovation [61].

Ereğli Iron and Steel Factories Inc. (EREGL) (β_4): Founded in 1960, EREGL is one of Türkiye's leading steel producers. The company has gained global significance in steel production and serves industries such as automotive, construction, home appliances, and machinery. ERGL provides high-quality steel products through its integrated production facilities and maintains its industry leadership with environmentally friendly production techniques. The company also holds a strong market share in both national and international markets and is focused on sustainable production goals [62].

Turkish Glass and Bottle Factories Inc. (SISE) (β_5): Founded in 1935, SISE is Türkiye's largest glass manufacturer. The company produces a wide range of glass products, including automotive glass, construction glass, industrial glass, and household items. SISE serves a large customer base in the global market and makes significant investments in innovation, quality management, and sustainable production processes. The company strengthens its industry presence with environmentally friendly production practices and efficient resource use while embracing sustainability principles [63].

Hacı Ömer Sabancı Holding Inc. (SAHOL) (β_6): Established in 1967, SAHOL is Türkiye's largest conglomerate. Operating in various sectors including energy, retail, industry, financial services, and construction, Sabancı Holding houses major brands such as Akbank, Carrefoursa, Çimsa, and Temsa. The company has a strong presence in both local and international markets and has made significant strides in sustainability and corporate social responsibility. Through investments focused on innovation and technology, Sabancı Holding strengthens its growth strategies on a global scale [64].

Anadolu Group Holding (AGHOL) (β_7): Established in 1950, AGHOL is one of Türkiye's Türkiye's leading conglomerates. The company operates in sectors such as beverages, retail, automotive, energy, and industry. Among the major brands under Anadolu Group are Coca-Cola beverage, Migros, Anadolu Efes, and Ford Otosan. The group has a strong presence in the local market while also expanding its influence in international markets. Anadolu Group places significant importance on sustainability and corporate social responsibility, investing in innovation and environmentally friendly technologies in line with these values [65].

Turkish Telecommunications Inc. (TTKOM) (β_8): Established in 1995, TTKOM is Türkiye's largest telecommunications company. It offers a wide range of services, including fixed-line phones, internet, mobile services, and digital television. The company strengthens its leadership in the sector through investments in digitalization and technology, with a significant focus on innovative projects such as 5G technology and digital services. Türk Telekom plays a leading role in the technological transformation process and contributes to Türkiye's digital infrastructure by offering various solutions to its customers [66].

Birleşik Mağazalar Inc. (BIMAS) (β_9): Founded in 1995, BİM is one of Türkiye's largest retail chains. With a low-price strategy, BİM caters to a broad customer base by offering essential food and consumer goods at affordable prices. The company operates thousands of stores across Türkiye, maintaining its leadership in the industry through efficient supply chain management and effective operational processes. BİM has a competitive advantage by focusing on sustainable business models and efficient resource utilization in both local and global markets [67].

Turkcell Communication Services Inc. (TCELL) (β_{10}): Founded in 1994, TCELL is one of Türkiye's leading mobile communication service providers. The company offers a broad range of services including mobile communication, internet, digital services, and financial services. Turkcell has taken significant steps in the digitalization process, developing innovative solutions such as 5G technology and digital payment systems, continuously improving the user experience. The company also contributes to the sector's development with sustainable practices and environmentally friendly operations. Turkcell has become a prominent brand globally with its digital solutions and technological infrastructure [68]. The decision model for the application is presented in Figure 2.

4.3 Assessing financial Performance of Companies using the CRITIC-MABAC Method

In this study, the CRITIC-MABAC method was used to determine and rank the financial performance of the top ten companies listed in the sustainability index. By sequentially applying the CRITIC-MABAC algorithm steps, the importance levels of financial performance criteria and the financial performance of the companies were identified. The implementation steps and findings are as follows:

Stage 1: Objective weighting of criteria using the CRITIC method for criteria prioritization:

Step 1-1: In the first step, the initial decision matrix ($\mathfrak{F} = [\mathfrak{F}_{ij}]_{L \times F}$) was constructed for twelve criteria and ten alternatives. The financial ratio values for the criteria were calculated based on data obtained from the financial documents of the companies. The financial values of each company based on the criteria (the initial decision matrix) are presented in Table 3.

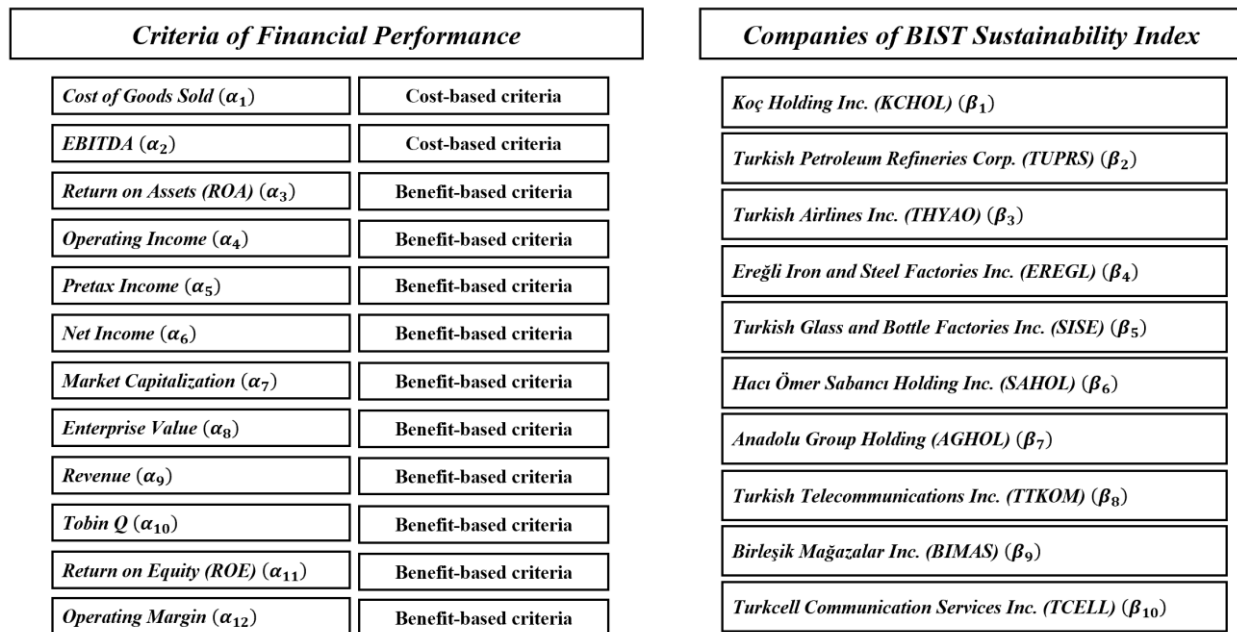


Fig. 2. The decision model

Table 3

The initial decision matrix

	α_1	α_2	α_3	α_4	α_5	α_6
β_1	995,950.00	14.91	1.86	222,656.00	152,695.00	72,230.00
β_2	576,796.12	14.02	2.45	73,627.77	57,820.36	53,577.34
β_3	384,952.00	23.37	21.00	71,425.00	91,282.00	162,998.00
β_4	133,658.00	12.20	0.62	13,334.60	9,209.90	4,203.20
β_5	110,055.80	15.26	5.09	15,718.43	23,589.94	17,121.37
β_6	115,931.17	23.04	0.92	124,423.73	47,952.86	15,427.32
β_7	276,294.88	9.38	1.17	17,636.34	59,568.68	19,638.48
β_8	78,315.94	32.77	5.00	4,858.25	3,430.23	16,421.55
β_9	276,759.30	4.37	6.63	3,960.10	22,044.60	15,440.70
β_{10}	84,418.04	39.19	5.60	23,597.75	5,886.68	12,554.00
	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}
β_1	359,463.00	251,001.00	1,219,023.00	0.25	7.88	18.27
β_2	275,531.83	192,834.71	686,528.51	0.65	8.99	10.72
β_3	315,468.03	209,477.56	504,398.00	0.37	44.32	14.16
β_4	143,500.00	190,605.30	147,899.80	0.68	1.29	9.02
β_5	140,356.47	220,405.22	151,994.02	0.68	8.56	10.34
β_6	123,342.42	-161,507.17	137,009.16	0.14	4.22	90.81
β_7	48,926.18	184,861.53	375,583.48	0.34	5.59	4.70
β_8	85,260.00	145,426.10	100,184.66	0.57	10.49	4.85
β_9	182,615.40	204,325.00	328,441.90	1.06	13.53	1.21
β_{10}	123,420.00	155,741.73	107,116.18	0.84	9.63	22.03

Step 1-2: In the second step, the max-min normalization process shown in Eq. (1) was applied. Subsequently, the normalized decision matrix ($\mathcal{Z} = [\mathcal{Z}_{\ell\beta}]_{\mathcal{LF}}$) was obtained, standardizing the financial data. The normalized decision matrix is presented in Table 4.

Step 1-3: In the third step, the correlation relationships among the criteria, which play a significant role in determining criterion weights, were identified. In this context, the relationship coefficient matrix ($\mathcal{C} = [\mathcal{C}_{\beta\beta'}]_{\mathcal{FF}}$) was determined using Eq. (2). This matrix is presented in Table 5.

Table 4
 The normalized decision matrix

	α_1	α_2	α_3	α_4	α_5	α_6
β_1	0.0000	0.6974	0.0610	1.0000	1.0000	0.4284
β_2	0.4568	0.7228	0.0897	0.3186	0.3644	0.3109
β_3	0.6658	0.4544	1.0000	0.3085	0.5886	1.0000
β_4	0.9397	0.7752	0.0000	0.0429	0.0387	0.0000
β_5	0.9654	0.6874	0.2193	0.0538	0.1351	0.0814
β_6	0.9590	0.4638	0.0151	0.5508	0.2983	0.0707
β_7	0.7843	0.8561	0.0269	0.0625	0.3761	0.0972
β_8	1.0000	0.1843	0.2153	0.0041	0.0000	0.0769
β_9	0.7837	1.0000	0.2950	0.0000	0.1247	0.0708
β_{10}	0.9934	0.0000	0.2445	0.0898	0.0165	0.0526
	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}
β_1	1.0000	1.0000	1.0000	0.1185	0.1533	0.1904
β_2	0.7297	0.8590	0.5241	0.5543	0.1790	0.1062
β_3	0.8583	0.8993	0.3613	0.2474	1.0000	0.1446
β_4	0.3045	0.8536	0.0426	0.5893	0.0000	0.0872
β_5	0.2944	0.9258	0.0463	0.5870	0.1690	0.1020
β_6	0.2396	0.0000	0.0329	0.0000	0.0680	1.0000
β_7	0.0000	0.8397	0.2461	0.2206	0.0999	0.0389
β_8	0.1170	0.7441	0.0000	0.4694	0.2138	0.0407
β_9	0.4305	0.8868	0.2040	1.0000	0.2844	0.0000
β_{10}	0.2399	0.7691	0.0062	0.7620	0.1937	0.2324

Table 5
 The relationship coefficient matrix

	α_1	α_2	α_3	α_4	α_5	α_6
α_1	1.0000	-0.3404	0.0094	-0.7877	-0.8972	-0.5024
α_2	-0.3404	1.0000	-0.2296	0.0312	0.2502	-0.0517
α_3	0.0094	-0.2296	1.0000	-0.0986	0.1563	0.8047
α_4	-0.7877	0.0312	-0.0986	1.0000	0.8651	0.4073
α_5	-0.8972	0.2502	0.1563	0.8651	1.0000	0.6585
α_6	-0.5024	-0.0517	0.8047	0.4073	0.6585	1.0000
α_7	-0.8284	0.1684	0.3986	0.6860	0.7641	0.7533
α_8	-0.3984	0.2859	0.2497	-0.1574	0.1899	0.2704
α_9	-0.9985	0.3359	0.0172	0.7841	0.9128	0.5266
α_{10}	0.3276	0.0869	0.0437	-0.6669	-0.6341	-0.3654
α_{11}	-0.1235	-0.1690	0.9839	0.0196	0.2942	0.8850
α_{12}	0.1442	-0.2676	-0.1949	0.4513	0.0933	-0.0848
	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}
α_1	-0.8284	-0.3984	-0.9985	0.3276	-0.1235	0.1442
α_2	0.1684	0.2859	0.3359	0.0869	-0.1690	-0.2676
α_3	0.3986	0.2497	0.0172	0.0437	0.9839	-0.1949
α_4	0.6860	-0.1574	0.7841	-0.6669	0.0196	0.4513
α_5	0.7641	0.1899	0.9128	-0.6341	0.2942	0.0933
α_6	0.7533	0.2704	0.5266	-0.3654	0.8850	-0.0848
α_7	1.0000	0.3644	0.8232	-0.1752	0.4881	-0.0803
α_8	0.3644	1.0000	0.4095	0.4248	0.2394	-0.9267
α_9	0.8232	0.4095	1.0000	-0.3487	0.1508	-0.1535
α_{10}	-0.1752	0.4248	-0.3487	1.0000	-0.0716	-0.5562
α_{11}	0.4881	0.2394	0.1508	-0.0716	1.0000	-0.1673
α_{12}	-0.0803	-0.9267	-0.1535	-0.5562	-0.1673	1.0000

Step 1-4: In the fourth step, the information value is calculated by considering the correlation relationships among the criteria and the standard deviation values of the criteria. This calculation is performed using Eq. (3). The information matrix ($\mathfrak{Y} = [\mathfrak{Y}_{\ell\mathfrak{f}}]_{\mathcal{F}}$) is presented in Table 6.

Table 6
 The information matrix

	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}
$\mathfrak{Y}_{\mathfrak{f}}$	0.0000	0.6974	0.0610	1.0000	1.0000	0.4284	1.0000	1.0000	1.0000	0.1185	0.1533	0.1904

Step 1-5: In the fifth step, the linear normalization process presented in Eq. (4) is applied to determine the final criterion weights of the financial ratios. The criterion weight matrix ($\varpi = [\varpi_{\mathfrak{f}}]_{\mathcal{F}}$) is presented in Table 7.

Table 7
 The criterion weight matrix

	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}
$\varpi_{\mathfrak{f}}$	0.1319	0.0909	0.0707	0.0820	0.0705	0.0634	0.0683	0.0768	0.0732	0.1077	0.0641	0.1005
Rank	1 st	4 th	8 th	5 th	9 th	12 th	10 th	6 th	7 th	2 nd	11 th	3 rd

Stage 2: Assessing the financial performance of companies using the MABAC method:

Step 2-1: For financial performance calculation, the initial decision matrix ($\mathfrak{F} = [\mathfrak{F}_{\ell\mathfrak{f}}]_{\mathcal{L}\mathcal{F}}$) is the same as the one used in the criterion weighting method. This matrix is presented in Table 3.

Step 2-2: The second step of the MABAC method is the same as the second step of the CRITIC method, where the max-min normalization process presented in Eq. (1) is applied. The normalized decision matrix ($\mathfrak{Z} = [\mathfrak{Z}_{\ell\mathfrak{f}}]_{\mathcal{L}\mathcal{F}}$) has already been presented in Table 4.

Step 2-3: Using the criterion weights obtained through the CRITIC method and the criterion weight matrix presented in Table 7, the weighted decision matrix ($\mathfrak{X} = [\mathfrak{X}_{\ell\mathfrak{f}}]_{\mathcal{L}\mathcal{F}}$) is derived. This is achieved using Eq. (5). The weighted decision matrix is presented in Table 8.

Table 8
 The weighted decision matrix

	α_1	α_2	α_3	α_4	α_5	α_6
β_1	0.1319	0.1544	0.0750	0.1640	0.1410	0.0905
β_2	0.1922	0.1567	0.0770	0.1082	0.0962	0.0831
β_3	0.2198	0.1323	0.1413	0.1073	0.1120	0.1268
β_4	0.2559	0.1614	0.0707	0.0855	0.0732	0.0634
β_5	0.2593	0.1535	0.0862	0.0864	0.0800	0.0685
β_6	0.2584	0.1331	0.0717	0.1272	0.0915	0.0679
β_7	0.2354	0.1688	0.0726	0.0872	0.0970	0.0695
β_8	0.2639	0.1077	0.0859	0.0824	0.0705	0.0683
β_9	0.2353	0.1819	0.0915	0.0820	0.0793	0.0679
β_{10}	0.2630	0.0909	0.0879	0.0894	0.0717	0.0667

Table 8
 Continued

	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}
β_1	0.1367	0.1536	0.1464	0.1205	0.0739	0.1196
β_2	0.1182	0.1428	0.1115	0.1674	0.0755	0.1111
β_3	0.1270	0.1459	0.0996	0.1344	0.1281	0.1150
β_4	0.0891	0.1424	0.0763	0.1712	0.0641	0.1092
β_5	0.0884	0.1479	0.0766	0.1710	0.0749	0.1107
β_6	0.0847	0.0768	0.0756	0.1077	0.0684	0.2009
β_7	0.0683	0.1413	0.0912	0.1315	0.0705	0.1044
β_8	0.0763	0.1339	0.0732	0.1583	0.0778	0.1045
β_9	0.0977	0.1449	0.0881	0.2154	0.0823	0.1005
β_{10}	0.0847	0.1359	0.0736	0.1898	0.0765	0.1238

Step 2-4: The boundary proximity area was determined using Eq. (6). Thus, the boundary proximity area matrix ($\mathcal{D} = [\mathcal{D}_{\ell\mathcal{F}}]$) was obtained. This matrix is presented in Table 9.

Table 9
 The boundary proximity area matrix

	α_1	α_2	α_3	α_4	α_5	α_6	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}
\mathcal{D}_{ℓ}	0.2272	0.1413	0.0842	0.0994	0.0891	0.0755	0.0949	0.1344	0.0890	0.1535	0.0778	0.1175

Step 2-5: To calculate the boundary proximity area distances for each alternative, Eq. (7) was used. Thus, the distance matrix ($\mathcal{B} = [\mathcal{B}_{\ell\mathcal{F}}]_{\mathcal{LF}}$) was calculated and is presented in Table 10.

Table 10
 The distance matrix

	α_1	α_2	α_3	α_4	α_5	α_6
β_1	-0.0953	0.0131	-0.0092	0.0646	0.0519	0.0150
β_2	-0.0351	0.0154	-0.0072	0.0087	0.0071	0.0076
β_3	-0.0075	-0.0090	0.0571	0.0079	0.0229	0.0512
β_4	0.0286	0.0201	-0.0135	-0.0139	-0.0159	-0.0121
β_5	0.0320	0.0122	0.0020	-0.0130	-0.0091	-0.0070
β_6	0.0312	-0.0082	-0.0125	0.0278	0.0024	-0.0077
β_7	0.0081	0.0275	-0.0116	-0.0123	0.0079	-0.0060
β_8	0.0366	-0.0336	0.0017	-0.0170	-0.0186	-0.0073
β_9	0.0081	0.0406	0.0073	-0.0174	-0.0098	-0.0077
β_{10}	0.0357	-0.0504	0.0038	-0.0100	-0.0175	-0.0088
	α_7	α_8	α_9	α_{10}	α_{11}	α_{12}
β_1	0.0418	0.0192	0.0574	-0.0330	-0.0039	0.0020
β_2	0.0233	0.0083	0.0226	0.0139	-0.0022	-0.0064
β_3	0.0321	0.0114	0.0106	-0.0192	0.0504	-0.0026
β_4	-0.0057	0.0079	-0.0127	0.0177	-0.0137	-0.0083
β_5	-0.0064	0.0135	-0.0124	0.0174	-0.0029	-0.0068
β_6	-0.0102	-0.0576	-0.0134	-0.0458	-0.0093	0.0834
β_7	-0.0266	0.0069	0.0022	-0.0220	-0.0073	-0.0132
β_8	-0.0186	-0.0005	-0.0158	0.0048	0.0000	-0.0130
β_9	0.0029	0.0105	-0.0009	0.0619	0.0045	-0.0171
β_{10}	-0.0102	0.0014	-0.0153	0.0363	-0.0013	0.0063

Step 2-6: By combining the distances for each alternative across all criteria, the total distance matrix is calculated using Eq. (8). Finally, the ultimate total distance matrix ($\mathcal{U} = [\mathcal{U}_\ell]_{\mathcal{L}}$) is presented in Table 11.

Step 2-7: The companies' final financial performances were calculated by applying the linear normalization process presented in Eq. (9). Thus, the financial performances and rankings of the companies ($\mathcal{R} = [\mathcal{R}_\ell]_{\mathcal{L}}$) were determined. These are presented in Table 11.

Table 11

The ultimate total distance matrix

	β_1	β_2	β_3	β_4	β_5	β_6	β_7	β_8	β_9	β_{10}
\mathcal{U}_ℓ	0.1235	0.0560	0.2055	-0.0215	0.0194	-0.0199	-0.0463	-0.0813	0.0829	-0.0300
\mathcal{R}_ℓ	0.7142	0.4787	1.0000	0.2086	0.3514	0.2142	0.1220	0.0000	0.5727	0.1790
Rank	2 nd	4 th	1 st	7 th	5 th	6 th	9 th	10 th	3 rd	8 th

5. Results

In this study, the CRITIC-MABAC method was used to analyze the financial performance of the top ten companies listed in the sustainability index. The CRITIC weighting method was applied to determine the significant levels of financial ratios and their influence on the decision-making process. The MABAC ranking method was then employed to assess and rank the financial performance of the companies.

The study provides two key practical outcomes:

- *First outcome - CRITIC Method Results:* The importance of ranking of criteria is as follows: "Cost of Goods Sold (α_1) > Tobin Q (α_{10}) > Operating Margin (α_{12}) > EBITDA (α_2) > Operating Income (α_4) > Enterprise Value (α_8) > Revenue (α_9) > ROA (α_3) > Pretax Income (α_5) > Market Capitalization (α_7) > ROE (α_{11}) > Net Income (α_6)". According to this result, the criterion with the highest weight is "Cost of Goods Sold." This indicates that cost-related factors play a significant role in financial performance evaluation, suggesting that production costs have a substantial impact on overall financial performance. The criterion weights are illustrated in Figure 3. Interestingly, "Net Income" was identified as the criterion with the lowest weight. This finding suggests that assessing financial performance solely based on net income may be misleading.

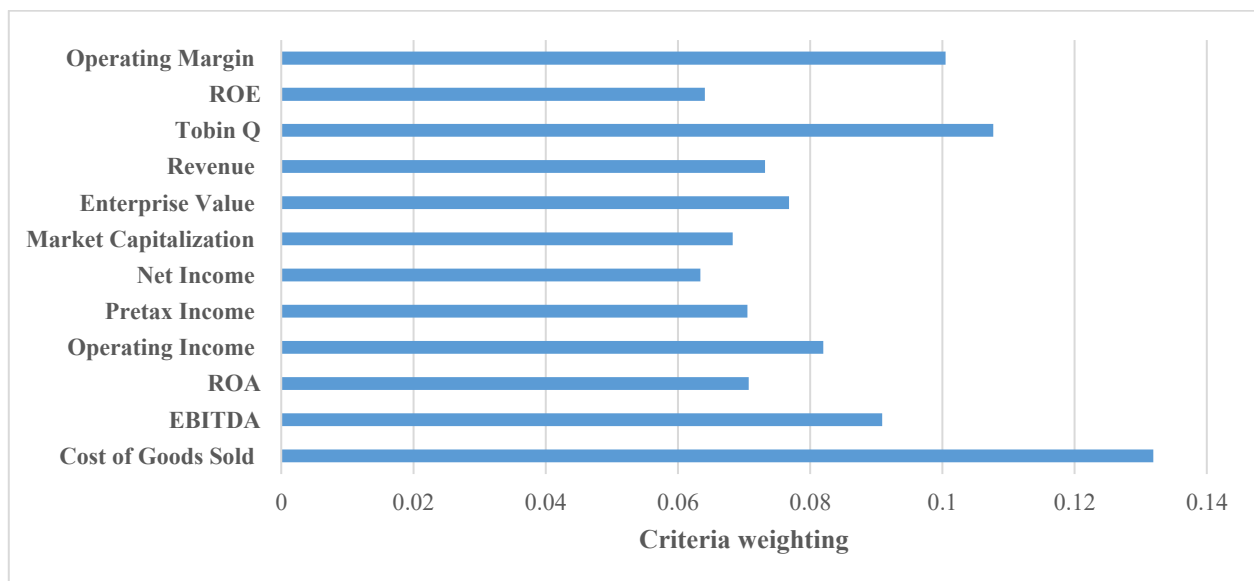


Fig. 3. Results of criteria weighting

- *Second outcome - MABAC Method Results:* The financial performance ranking of the companies is as follows: " Turkish Airlines Inc. (THYAO) (β_3) > Koç Holding Inc. (KCHOL) (β_1) > Birleşik Mağazalar Inc. (BIMAS) (β_9) > Turkish Petroleum Refineries Corp. (TUPRS) (β_2) > Turkish Glass and Bottle Factories Inc. (SISE) (β_5) > Hacı Ömer Sabancı Holding Inc. (SAHOL) (β_6) > Ereğli Iron and Steel Factories Inc. (EREGL) (β_4) > Turkcell Communication Services Inc. (TCELL) (β_{10}) > Anadolu Group Holding (AGHOL) (β_7) > Turkish Telecommunications Inc. (TTKOM) (β_8)". Based on this ranking, Turkish Airlines Inc. (THYAO) was identified as the company with the highest financial performance. The financial performance of the companies are illustrated in Figure 4. Additionally, Turkish Telecommunications Inc. (TTKOM) was determined to have the lowest financial performance among the companies in the decision model.

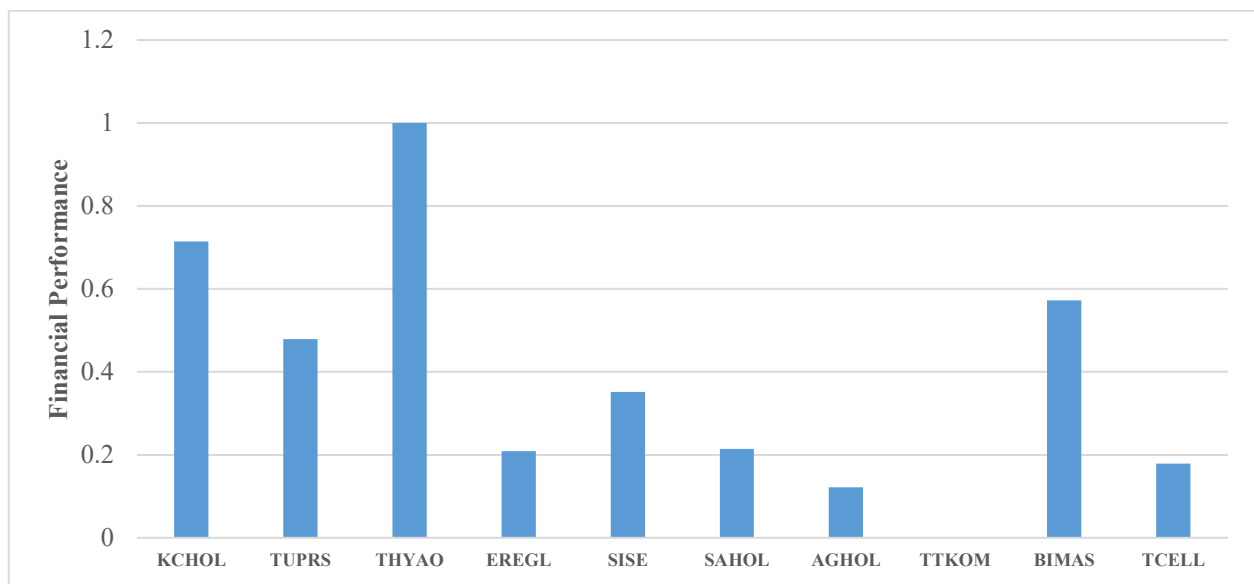


Fig. 4. Results of financial performance

Ultimately, the financial performance analysis was successfully conducted using the CRITIC-MABAC method. As a result, the financial performance of the top ten companies in the sustainability index for the year 2023 has been determined.

5.1 Sensitivity analysis for the CRITIC-MABAC Method

A sensitivity analysis was conducted to test the robustness of the CRITIC-MABAC method results. In this analysis, the companies included in the decision model were sequentially removed, and the CRITIC-MABAC method was re-applied at each step.

First, the company with the lowest financial performance in the initial results, TTKOM, was removed from the decision model, and the analysis was repeated. In this scenario, THYAO remained the best-performing company, while AGHOL was identified as the worst-performing company. Next, AGHOL was removed, and the analysis was performed again. As a result, THYAO retained its position as the best-performing company, whereas TCELL was determined to have the lowest financial performance. Following this, TCELL was excluded from the decision model, and the process was repeated. In this iteration, THYAO remained the best performer, while SAHOL was identified as the worst-performing company. When SAHOL was subsequently removed, the results changed for the first time, with KCHOL emerging as the best-performing company and EREGL as the worst-performing company. The analysis continued by removing EREGL, after which THYAO was again the best-

performing company, while SISE was the worst. When SISE was removed, THYAO remained the best, and TUPRS was found to have the lowest financial performance. Removing TUPRS resulted in THYAO still being the best, while BIMAS was identified as the worst-performing company. In the final step, a direct financial performance comparison was conducted between THYAO and KCHOL. In this case, KCHOL was identified as the best performing company. This change in ranking suggests that while THYAO consistently outperformed most companies, KCHOL demonstrated superior financial performance when directly compared to THYAO. According to the sensitivity analysis results, the ranking of companies based on their performance is presented in Table 12, while the financial performance results are illustrated in Figure 5. Overall, despite minor changes observed during the sensitivity analysis, the results confirm that the CRITIC-MABAC method is a robust approach for financial performance evaluation.

Table 12

The ranking of the sensitivity analysis

Scenarios	Ranking	Best Perf.	Worst Perf.
Result	$\beta_3 > \beta_1 > \beta_9 > \beta_2 > \beta_5 > \beta_6 > \beta_4 > \beta_{10} > \beta_7 > \beta_8$	THYAO	TTKOM
Removed 8 th Company	$\beta_3 > \beta_1 > \beta_9 > \beta_2 > \beta_5 > \beta_6 > \beta_4 > \beta_{10} > \beta_7$	THYAO	AGHOL
Removed 7 th Company	$\beta_3 > \beta_1 > \beta_9 > \beta_2 > \beta_5 > \beta_6 > \beta_4 > \beta_{10}$	THYAO	TCELL

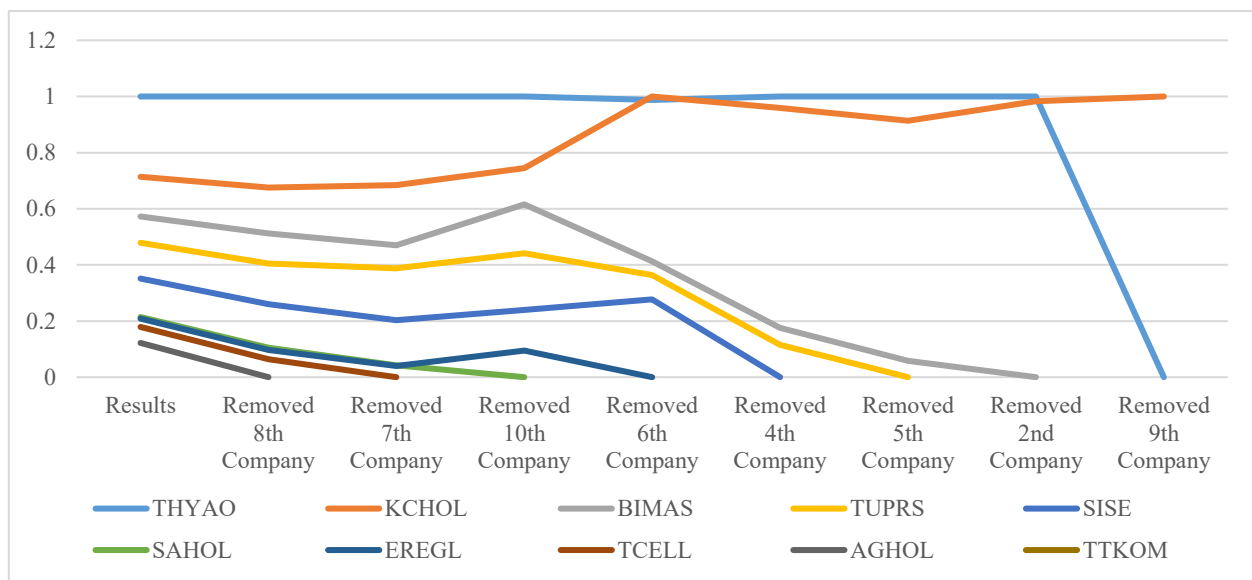


Fig. 5. Results of sensitivity analysis

5.2 Comparative analysis of the CRITIC-MABAC Method

A comparative analysis was conducted to test the consistency of the CRITIC-MABAC method's application results. For this comparison, five different methods that have been validated in the literature for robustness were applied: AROMAN (*An alternative ranking order method accounting for two-step normalization*) [69], MARCOS (*Measurement of alternatives and ranking according to Compromise solution*) [70], RAM (*Root Assessment Method*) [71], SAW (*Simple Additive Weighting*), and TOPSIS (*Technique for Order of Preference by Similarity to Ideal Solution*) [72]. The financial performance rankings of the companies according to each method are presented in Table 13, while Figure 6 illustrates the financial performance values of the companies for each method.

The comparison analysis results are as follows:

- When comparing the CRITIC-MABAC and AROMAN methods, both identified THYAO as the company with the highest financial performance and TTKOM as the company with the

lowest financial performance. Despite minor variations in rankings, the overall comparison results demonstrate consistency.

- Comparing CRITIC-MABAC with the MARCOS method, both approaches identified THYAO as the best-performing company. However, the lowest-performing companies differed: TTKOM in the MABAC method and EREGL in the MARCOS method. Despite this difference, a high level of consistency exists between the two methods.
- When CRITIC-MABAC is compared to the RAM method, the results align with those of the MARCOS method, where EREGL was identified as the lowest-performing company, and THYAO remained the best-performing company. This demonstrates consistency between these two methods.
- Comparing CRITIC-MABAC with the SAW method, both methods identified the same best-performing company. Although the lowest-performing companies differed, the overall financial performance rankings remained consistent.
- In the comparison between CRITIC-MABAC and TOPSIS, like the MARCOS and RAM methods, EREGL was identified as the lowest-performing company instead of TTKOM. However, the general ranking consistency between the TOPSIS and MABAC methods supports the reliability of the results.

Ultimately, in all methods, THYAO was identified as the company with the highest financial performance. This finding reinforces the consistency and validity of the CRITIC-MABAC method's results.

Table 13
 The ranking of the comparative analysis

Methods	Ranking	Best Perf.	Worst Perf.
CRITIC-MABAC	$\beta_3 > \beta_1 > \beta_9 > \beta_2 > \beta_5 > \beta_6 > \beta_4 > \beta_{10} > \beta_7 > \beta_8$	THYAO	TTKOM
AROMAN	$\beta_3 > \beta_1 > \beta_9 > \beta_2 > \beta_6 > \beta_5 > \beta_7 > \beta_4 > \beta_{10} > \beta_8$	THYAO	TTKOM
MARCOS	$\beta_3 > \beta_2 > \beta_5 > \beta_1 > \beta_{10} > \beta_7 > \beta_9 > \beta_8 > \beta_6 > \beta_4$	THYAO	EREGL
RAM	$\beta_3 > \beta_1 > \beta_6 > \beta_2 > \beta_9 > \beta_5 > \beta_{10} > \beta_7 > \beta_8 > \beta_4$	THYAO	EREGL
SAW	$\beta_3 > \beta_1 > \beta_9 > \beta_2 > \beta_5 > \beta_{10} > \beta_6 > \beta_8 > \beta_4 > \beta_7$	THYAO	AGHOL
TOPSIS	$\beta_3 > \beta_1 > \beta_6 > \beta_{10} > \beta_2 > \beta_9 > \beta_8 > \beta_5 > \beta_7 > \beta_4$	THYAO	EREGL

6. Implications

This study offers several significant implications for both academics and practitioners in the field of financial performance analysis and sustainability assessment. By employing the CRITIC-MABAC method, the research provides an alternative approach to evaluating the financial performance of companies listed on sustainability indices, specifically BIST. The CRITIC-MABAC methodology, which combines the objective weighting of criteria through CRITIC and the ranking of companies based on boundary proximity through MABAC, proves to be a reliable and consistent tool for assessing corporate financial performance. This method can be applied across various sectors to provide nuanced insights into financial performance, offering a robust framework for decision-making in focused financial analyses.

For academics, this study highlights the utility of MCDM techniques in corporate finance, particularly in the context of sustainable business practices. Researchers can further explore the use of CRITIC-MABAC and other MCDM approaches in different industrial contexts, refining the methodologies or integrating new variables to enhance the precision and applicability of these tools in sustainability assessments.

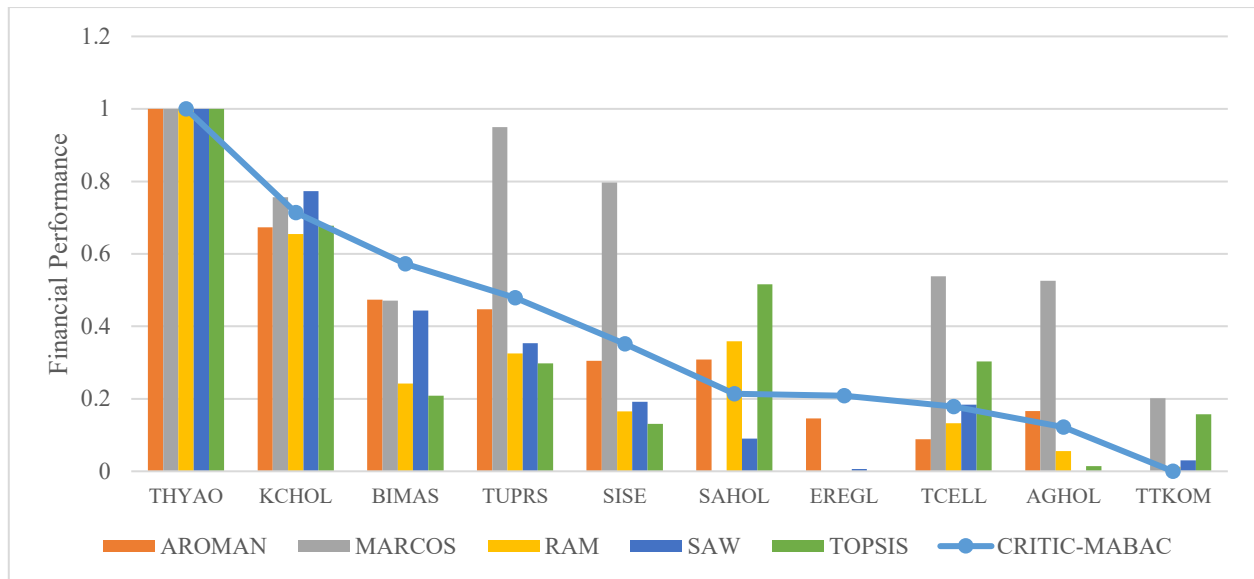


Fig. 6. Results of comparative analysis

For practitioners, the findings underscore the importance of incorporating comprehensive financial performance evaluations into sustainability strategies. The results from this study, particularly the identification of key financial ratios such as Cost of Goods Sold and Net Income, can inform investment decisions and strategic planning within companies aiming to improve both their sustainability practices and financial performance. Additionally, the study's sensitivity and comparison analyses demonstrate that the CRITIC-MABAC method offers consistent and reliable results, reinforcing its applicability as a valuable tool in financial decision-making and performance evaluation.

In sum, this research provides valuable insights into the financial performance of companies within sustainability indices and offers a novel methodological framework for practitioners and scholars interested in enhancing sustainability and financial performance analysis. The consistent findings across various MCDM methods further validate the robustness and applicability of the CRITIC-MABAC approach, suggesting its potential for wider adoption in both academic studies and real-world business practices.

7. Conclusions

The findings of this study indicate that the most critical financial criterion was found to be the "Cost of Goods Sold," while the least important criterion was identified as "Net Income." Through the MABAC method, the top financial performer among the selected companies was Turkish Airlines Inc. (THYAO), while Turkish Telecommunications Inc. (TTKOM) demonstrated the lowest financial performance in the decision model. The results of this analysis provide an insightful view into the financial status of the leading firms in Turkey's sustainability index for the year 2023, offering valuable benchmarks for future evaluations.

Furthermore, sensitivity analysis confirmed the robustness of the CRITIC-MABAC methodology, with results indicating that under varying scenarios, Koç Holding Inc. (KCHOL) also emerged as a top performer. This reinforces the reliability and adaptability of the CRITIC-MABAC approach across different scenarios and corporate structures. Comparative analysis of alternative decision-making methods, including AROMAN, MARCOS, RAM, SAW, and TOPSIS, also supported the consistency of the CRITIC-MABAC results, with Turkish Airlines Inc. (THYAO) consistently being identified as the top financial performer across all methods.

In conclusion, this study highlights the efficacy of the CRITIC-MABAC methodology as a robust and reliable tool for financial performance evaluation. The method demonstrated consistent and credible results, establishing it as a valuable alternative approach to financial performance analysis. This research contributes to the body of knowledge in sustainable business practices by offering a reliable framework for assessing the financial sustainability of companies, particularly those listed in sustainability indices, thus facilitating informed decision-making for both investors and corporate strategists. Future research can further expand this methodology across different sectors and regions, providing broader insights into the relationship between financial performance and sustainability efforts.

While this research presents a robust application of the CRITIC-MABAC methodology to assess the financial performance of companies within the BIST Sustainability Index for the year 2023, it is important to acknowledge several limitations.

First, the study is based on a specific set of financial indicators, namely Cost of Goods Sold, EBITDA, ROA, Operating Income, Pretax Income, Net Income, Market Capitalization, Enterprise Value, Revenue, Tobin Q, ROE, and Operating Margin, which, although comprehensive, may not capture all the dimensions of a company's financial health. Other potential factors, such as market conditions, macroeconomic variables, or non-financial indicators related to ESG criteria, could provide a more holistic view of a company's performance and sustainability.

Second, the research focuses solely on the top ten companies in the BIST Sustainability Index for 2023, limiting the generalizability of the findings to other companies outside of this index or to different years. Expanding the scope to include a larger sample of firms or incorporating longitudinal analysis over multiple years could yield more generalized results and insights into trends in financial performance and sustainability. Additionally, while sensitivity analysis was conducted to assess the robustness of the results, the conclusions drawn are inherently based on the assumptions and parameters set within the CRITIC-MABAC model. The results may vary depending on the choice of method or the inclusion/exclusion of certain criteria. For instance, alternative MCDM methods or variations in the weighting of financial ratios could lead to different rankings of companies.

Lastly, the reliance on publicly available financial data means that the accuracy and completeness of the information could impact the validity of the analysis. Any errors or omissions in the financial reporting of the companies included in the study could affect the outcomes of the financial performance evaluation.

This study provides valuable insights into the financial performance analysis of companies listed in the BIST Sustainability Index using the CRITIC-MABAC methodology. However, there are several avenues for future research that could build upon the findings and further enhance the understanding of financial performance in the context of sustainability. *(i)* While the study focused on twelve financial ratios, future research could expand the set of criteria to include non-financial indicators such as ESG metrics. *(ii)* This research analyzed the financial performance of the top ten companies in the BIST Sustainability Index for a single year, 2023. Future studies could extend the analysis over multiple years to observe trends and fluctuations in financial performance over time. *(iii)* While this study focused on a specific subset of companies from the BIST Sustainability Index, future research could broaden the scope to include a larger sample of firms, both from different sustainability indices and across various sectors. *(iv)* Future studies could focus on sector-specific analyses by applying the CRITIC-MABAC method to companies within industries. This would allow for a more tailored approach to evaluating financial performance and sustainability, accounting for the unique challenges and opportunities faced by different sectors, such as technology, energy, or manufacturing.

Appendix

Notation

Indices and sets	
$\ell = 1, 2, \dots, \mathcal{L}$	index of companies,
$f = 1, 2, \dots, \mathcal{F}$	index of criteria,
$\beta = \{\beta_1, \beta_2, \dots, \beta_\ell, \dots, \beta_{\mathcal{L}}\}$	set of companies,
α $= \{\alpha_1, \alpha_2, \dots, \alpha_f, \dots, \alpha_{\mathcal{F}}\}$	set of criteria,
$\alpha^- \subseteq \alpha$	set of the cost-based criteria,
$\alpha^+ \subseteq \alpha$	set of the benefit-based criteria,
Parameters	
$\mathcal{L} \geq 2$	number of companies,
$\mathcal{F} \geq 2$	number of criteria,
Variables	
$\mathfrak{F}_{\ell f}(\ell \in \beta, f \in \alpha)$	value of the company β_ℓ depending on the criterion α_f ,
$\mathfrak{Z}_{\ell f}(\ell \in \beta, f \in \alpha)$	normalized value of the company β_ℓ depending on the criterion α_f ,
$\mathfrak{C}_{ff'}(f \in \alpha, f' \in \alpha)$	coefficient value of criterion $\alpha_{f'}$ depending on the criterion α_f ,
$\mathfrak{V}_f(f \in \alpha)$	information value of the criterion α_f ,
$\mathfrak{W}_f(f \in \alpha)$	weighed of the criterion α_f ,
$\mathfrak{X}_{\ell f}(\ell \in \beta, f \in \alpha)$	weighted value of the company β_ℓ depending on the criterion α_f ,
$\mathfrak{D}_f(f \in \alpha)$	boundary proximity area of criterion α_f ,
$\mathfrak{B}_{\ell f}(\ell \in \beta, f \in \alpha)$	boundary proximity area distances value of the company β_ℓ depending on the criterion α_f ,
$\mathfrak{U}_\ell(\ell \in \beta)$	ultimate total distance value of the company β_ℓ ,
$\mathfrak{R}_\ell(\ell \in \beta)$	final financial performance of the company β_ℓ ,

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Conflicts of Interest

The authors declare no conflicts of interest.

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