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Evaluation of the Corporate Sustainability Performance of Manufacturing Companies in the BIST Sustainability Index with Multi-Criteria Decision Making Methods

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Abstract: *This study aims to evaluate the corporate sustainability performance of manufacturing companies listed in the Borsa Istanbul (BIST) Sustainability Index using multi-criteria decision-making (MCDM) methods. For this purpose, by examining the literature, 11 criteria, including economic, social, and environmental, were determined and the criteria were weighted with method based on the removal effects of criteria (MEREC), one of the objective MCDM methods. According to the weights obtained through the MEREC method, the most important criteria were "return on equity", "operating profitability", and "asset profitability", while the least important criteria were "employee turnover rate", "training hours per employee" and "proportion of female employees". Subsequently, using the weights derived from the MEREC method, the companies were ranked using the CoCoSo (Combined Compromise Solution) method. According to the rankings, the companies demonstrating the highest corporate sustainability performance are Türk Traktor, Ford, Tofaş, and Otokar, while the companies with the lowest corporate sustainability performance are Kerevitaş, Coca-Cola, Petkim, and Tüpraş, respectively. Sensitivity analysis is carried out to test the consistency of the results obtained. Although these results contribute to the literature, in subsequent studies, MEREC and CoCoSo methods can be used to measure different performance criteria of companies. The fact remains that corporate sustainability performances of companies can be measured by using combinations of different MCDM methods.*

Keywords: Corporate Sustainability, BIST Sustainability Index, Corporate Sustainability Performance, MEREC, CoCoSo

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1. Introduction

The world population, which did not even reach 2 billion until the beginning of the 20th century, has exceeded 8 billion since the first world war, and the sharing of the limited resources in the world among people has increased the discussions. The rapid and uncontrolled use of resources in a relatively short period of 80-90 years has jeopardized the idea of future generations living in prosperity. This situation has compelled countries to take precautions to prevent resource waste, and as a result, the concept of "sustainability" which we frequently hear about recently, has entered our lives. The concept of sustainability first emerged at the United Nations Conference on the Human Environment held in Stockholm in 1972 (Öztel et al., 2018: 2). Since

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then, sustainability, one of the most studied areas, implies not only minimizing environmental impacts but also ensuring the sustainability of economic and social resources for the continuous existence of all living beings. Although there is no universally accepted definition of sustainability, it emphasizes not only the efficient allocation of resources over time but also the fair distribution of resources and opportunities between the present and future generations and an economic activity scale related with ecological life support systems (Gray & Milne, 2002: 2).

Being cautious in the use of scarce resources carries great importance in today's business world, and sustainability activities have become a corporate characteristic rather than individual efforts. Initially, corporate sustainability was seen as utopian, irrelevant, and even destructive, but it has gradually become mainstream. In recent years, four-fifths of Fortune 500 global companies publish sustainability reports describing a wide variety of environmentally friendly activities. Most leading business schools offer corporate sustainability courses aiming to create a sustainable world through the power of companies (Lyon et al., 2018: 5). These developments put forth the importance given to corporate sustainability by both the business and the academic world.

Today's companies willingly share their corporate sustainability performance with all stakeholders they are responsible for by reporting their performance. This not only enhances the value of companies in the eyes of their consumers or potential consumers but also fulfills their function of "being beneficial to society”, which is one of their fundamental purposes. Global Reporting Initiative (GRI) is the globally accepted reporting standard to provide a common language in corporate sustainability reporting. GRI has pioneered the development of the most widely used sustainability reporting framework in the world and is a network-based organization dedicated to continuous improvement and global implementation. Companies in Turkey also use this standard in their corporate sustainability reporting.

This study aims to evaluate the sustainability performance of manufacturing companies listed on the Borsa Istanbul (BIST) Sustainability Index using multi-criteria decision-making (MCDM) methods. Especially manufacturing sector has the largest negative environmental impact. Additionally, factors such as higher initial investments, consequently higher financial needs, greater employment requirements, and much more need for qualified workforce compared to other sectors have influenced the selection of the manufacturing sector as a sample in this study. In the evaluation process, the MEREC (Method based on the Removal Effects of Criteria) and CoCoSo (Combined Compromise Solution) methods, which are MCDM methods, were preferred. Among the objective weighting methods, MEREC was preferred due to reasons such as not requiring expert opinion, being easily applicable, relying on a strong mathematical foundation, and not requiring a special software package for the solution. CoCoSo, which is used for ranking alternatives, uses a comparable sequence and then aggregates weights in two ways. One is the ordinary multiplication rule, and the other is the weighted power of distance from the comparable sequence. In other words, to validate the ranking index, three different measures (summation strategies) are defined for a specific alternative. The absence of any algorithm among the MCDM tools that offers a consensus-based solution like the CoCoSo method has influenced the choice of using it in this study (Yazdani et al., 2019: 2506). To test the consistency of the findings, a sensitivity analysis was conducted using different MCDM methods.

Even though many studies in which corporate sustainability performance is measured by MCDM methods have found their place in the literature (Rabbani et al., 2014; Alp et al., 2015; Rao, 2021) no research has been found in which corporate sustainability performance is measured with MEREC or CoCoSo methods. Although there are studies in the MCDM literature in which these relatively new methods are used together (Bektaş, 2022; Marinkovic et al., 2022; Simic et al., 2022), it can be considered as a new combination for corporate sustainability performance. In these respects, the study produces original results and contributes to the literature.

The remainder of the study is structured as follows. Firstly, the conceptual framework is given in the second section. The literature in the third section review includes studies that evaluate corporate sustainability performance using MCDM methods and studies that examine the application of these methods in specific decision problems. In the material and method in the fourth section, the data of the sample companies are shared and the solution algorithms of the MCDM methods used are presented. After the research findings are given in the fifth section, the results of the application and the discussion with the existing literature are included in the sixth chapter. In the seventh section, the study is concluded by giving place to the conclusions, limitations, and recommendations for future studies.

2. Conceptual Framework

2.1. Sustainability and Corporate Sustainability

Nowadays, perusing business websites or official reports without encountering references to "corporate sustainability" has become nearly impossible. Business schools around the world are now employing expert professors in the field of sustainability, and many major companies require employees capable of filling sustainability-related positions. These global developments in corporate sustainability have led to an increasing focus of academic research on corporate sustainability (Montiel & Delgado-Ceballos, 2014: 1). The concept of sustainability, which we have frequently encountered in recent years, has emerged from concerns about the degradation of natural resources and the worsening of economic and social development. As these issues have attained global proportions and the need for countries to devise policies addressing them has become evident, the United Nations established the "World Commission on Environment and Developm6ent (WCED)" (Akıncı & Akıncı, 2010: 194). The concept of "Sustainable Development" was first defined in the 1987 Brundtland Report as "meeting the needs of the present without compromising the ability of future generations to meet their own needs" (Bruntland, 1987; İMKB, 2011: 1). Starting from this point of view the concept of corporate sustainability has become identified with sustainable development and is expressed as the realization of sustainability at the organizational level (Engin & Akgöz, 2013: 85). Corporate sustainability, which arises as a necessity of businesses' economic, social, and environmental responsibilities, is grounded on stakeholder, agency and legitimacy theories (Hillman & Keim, 2001: 125-126; Kurnaz & Kestane, 2016: 280). These theories, embedded in the theoretical and rational origins of corporate sustainability, form the basis for understanding the significance of sustainability and its development (Taştan, 2021: 49).

One of the foundational theories within the realm of sustainability is the stakeholder theory, which underscores the imperative for businesses to take into account the interests of all stakeholders, encompassing not only shareholders but also a broader array of involved parties, in order to sustain their organizational presence (Temiz et al., 2022: 865). The underpinning of the pivotal concept of stakeholders, a critical facet of business sustainability, is based on Freeman's seminal work called "Strategic Management: A Stakeholder Approach" (1984). In accordance with Freeman's perspective (1984: 25), stakeholders are constituted by groups or individuals who can influence the achievement of business, and also who themselves are subject to the consequences of such influence. Stakeholders encompass a spectrum ranging from employees, customers, suppliers, shareholders, and financial institutions to environmental advocates, governmental entities, and other entities that wield the potential to either contribute or impede the organization's endeavors. According to Clarkson (1995: 106, 112), stakeholders, constitute individuals with vested ownership and ownership-related claims. Once primary stakeholder groups, such as customers and suppliers, are dissatisfied and left the corporate system completely or partially, the company will take a hammering and and become unsustainable. Consequently, the viability of a company is contingent upon its ability to fulfill stakeholder expectations, encompassing not merely shareholders, employees, and customers, but also extending to suppliers, government officials, local communities, the wider civil society, financial partners, and analogous stakeholders within an intricate network (Perrini & Tencati, 2006: 297). Thus, companies are tasked with the imperatively considering the interests of stakeholders, encompassing suppliers, employees, and customers, in conjunction with governmental entities, local communities, strategic partners, and civil society organizations, as they conduct their operational activities (Freeman, 1984: 27).

The stakeholder theory has contributed to the advancement of the legitimacy theory, which posits that companies should adhere to ethical and legitimate practices to positively influence stakeholders. This contribution stems from the notion that all stakeholders share universal ethical principles (Temiz et al., 2022:

865). The legitimacy theory is concerned with the harmonization of corporate values with societal values. By maintaining this alignment in their managerial endeavors and engaging with the broader society during their operations, companies can foster long-term sustainability and gain competitive advantages (Suchman, 1995: 571; Hillman & Keim, 2001: 127). In essence, legitimacy is achieved when companies operate in accordance with prevailing social norms and values.

Another pivotal theory pertaining to company sustainability is the agency theory, which encompasses the relationships inherent in agency dynamics. An agency relationship involves one or more individuals (principals) delegating authority to one or more others (agents) to act on their behalf, make decisions, and provide specific services for mutual benefit. A company entity represents a composite contractual structure characterized by joint input generation, involvement of various input providers, and a party common to all contracts. When a company, owned by shareholders (principals), is solely managed by contractually-bound executives (agents), and both parties seek to maximize utility, instances might arise where executives do not consistently act in alignment with shareholders' interests. Such deviations could compromise the maximization of company value and the welfare of shareholders, leading to agency problems among shareholders, creditors, and executives (Jensen & Meckling, 1976: 5). In essence, this theory underscores that executives (agents) possess an informational edge concerning the company and may exploit this information for personal gain. Consequently, conflicts of interest between business proprietors and executives contribute to agency predicaments and associated costs. To alleviate these issues and enhance accountability between executives, shareholders, and other stakeholders, practices such as sustainability reporting and initiatives aimed at enhancing the credibility of information in these reports (via independent assurance services) play a pivotal role (Temiz et al., 2022: 865-866).

2.2. Sustainability Performance, Sustainability Reporting and Sustainability Index

The sustainability index is a system designed to measure the financial indicators of businesses that prioritize environmental protection over profit-seeking. In a sense, it represents the reflection of corporate sustainability in financial markets and serves as a significant factor that encourages the preparation of sustainability reports (Altınay et al., 2017: 208; Yıldırım et al., 2018: 93). The world's first sustainability index is "Domini 400 Social Index," established in 1990, which conducted research for institutional investors. Sustainability practices in Turkey began in 2014. The index, which is in the stock markets of developed countries, operates under the name "Sustainability Index" on Borsa İstanbul (BIST) in Turkey (Altınay et al., 2017: 213). The objective of the index is to create a platform where companies with high levels of corporate sustainability performance traded on Borsa İstanbul can be featured. This aims to enhance awareness of environmental, social responsibility, and corporate governance issues within companies and promote the increase in sustainability practices among them (BIST, 2023).

In today's world, global companies, particularly in developed countries, are facing increasing pressure to adhere to sustainability criteria. As a result, companies now view disclosing their levels of alignment with economic, social, and environmental factors as a necessity (Kurnaz & Kestane, 2016: 280). In this context, in order to achieve sustainability goals, it is imperative for companies to measure and report every activity conducted during a given period (Altınay et al., 2017: 213).

Sustainability performance refers to the evaluation of a company's activities in prioritizing environmental, social, and economic dimensions over profit-seeking (Zimek & Baumgartner, 2017: 4). On the other hand, sustainability reporting is a corporate document that values all stakeholder groups, contributes to the continuity of corporate performance, and assesses economic, social, and environmental aspects (Kasbun et al., 2016: 80; Düzer & Önce, 2018: 95). The core objective of sustainability reporting is to provide a reliable and transparent presentation of businesses' economic, social, and environmental performances to all stakeholders. Certain non-governmental organizations have emerged to offer guidance to businesses engaging in sustainability reporting (Korga & Aslanoğlu, 2022: 634). A globally recognized and commonly adopted framework for sustainability reporting employed by businesses during report preparation is the GRI reporting framework (Nobanee & Ellili, 2016: 2). GRI serves as an international independent entity facilitating businesses, governments, and other institutions to comprehend and communicate the influence of businesses on vital sustainability matters including climate change, environmental degradation, human rights, equality, social disparities, and corruption (Düzer & Önce, 2018: 95).

The measurement of corporate sustainability performance aims to holistically address the environmental, social, and economic dimensions of corporate sustainability. Yet, issues emerge when endeavoring to examine these three dimensions by reducing them to a solitary dimension. In this context, multi-criteria decision-making approaches present a constructive framework for jointly evaluating these variables. Consequently, this study investigates the corporate sustainability performance of production enterprises encompassed within the corporate sustainability index.

3. Literature Review

There is a rich body of literature on the measurement of corporate sustainability performance. Numerous researchers have evaluated the corporate performance of various sectors or countries using various methods based on MCDM methods. The studies in the literature that assess corporate sustainability performance using MCDM methods are presented in Table 1.

In this study, the objective weighting method employed for the prioritization of selected criteria is the MEREC method introduced by Keshavarz-Ghorabaee et al. (2021) to the literature. The MEREC method has been utilized to weight the criteria in numerous decision problems, such as food waste treatment technology selection (Rani et al., 2021), assessment of countries based on social development index (Ayçin & Arsu, 2021), evaluation of countries' innovation performance (Ersoy, 2022), selection of green renewable energy sources (Goswami et al., 2022), sustainable material selection (Haq et al., 2022), evaluation of alternative-fueled vehicles (Hezam et al., 2022), assessment of low-carbon tourism strategies (Mishra et al., 2022), performance evaluation of logistics companies (Toslak et al., 2022), selection of pallet trucks (Ulutaş et al., 2022), and laptop selection (Yenilmezel & Ertuğrul, 2023).

The CoCoSo method, which was introduced to the literature by Yazdani et al. (2019), has been used to choose among alternatives or rank alternatives in many decision problems such as sustainable supplier selection (Ecer & Pamucar, 2020), financial performance analysis (Akgül, 2021; Topal, 2021; Çilek, 2022), autonomous vehicle selection (Deveci et al., 2021), evaluation of circular economy practices (Khan & Haleem, 2021), assessment of the healthcare sector (Torkayesh et al., 2021), stock portfolio selection (Narang et al., 2022), occupational health and safety risk assessment (Chen et al., 2022), evaluation of alternative railway systems (Bouraima et al., 2023), and location selection for electric vehicle charging stations (Zhang & Wei, 2023).

Furthermore, studies can be found in the literature that have used both the MEREC and CoCoSo methods together. MEREC and CoCoSo methods were used together in decision problems such as performance evaluation of insurance companies (Bektaş, 2022), selection of waste and recycled materials for road construction (Marinkovic et al., 2022), aircraft selection for flight schools (Özdağoğlu et al., 2022), assessment of urban transportation plans (Simic et al., 2022), financial performance evaluation of lodging and tourism industries (Ghosh & Bhattacharya, 2022), evaluation of countries' innovation performance (Ecer & Ayçin, 2023), and assessment of airport service quality (Sümerli Sarıgül et al., 2023).

With the comprehensive literature review, no studies were found that specifically evaluated corporate sustainability performance using either MEREC or CoCoSo methods. This study, which employs the relatively new methods of MEREC and CoCoSo in the context of corporate sustainability performance evaluation, is therefore considered an original contribution to the literature.

Table 1. Studies Evaluating Corporate Sustainability Performance Using MCDM Methods

	Methods												
Author/Year	**DEA**	**TOPSIS**	**VIKOR**	**MAUT**	**ARAS**	**ANP**	**GRA**	**EDAS**	**DEMATEL**	**COPRAS**	**Entropy**	**CRITIC**	**AHP**
Mei et al. (2011)													√
Rabbani et al. (2014)						√				√			
Özçelik & Avcı Öztürk (2014)							√						
Acar et al. (2015)		√											
Alp et al. (2015)				√							√		
Goyal et al. (2015)													√
Medel-Gonzalez et al. (2015)						√							√
Rebai et al. (2016)													√
Aras et al. (2017)		√											
Escrig-Olmedo et al. (2017)		√											
Engida et al. (2018)	√												
Aras et al. (2018)		√									√		
Öztel et al. (2018)		√									√		
Sofyalıoğlu & Sürücü (2018)		√											√
Tseng et al. (2019)									√				
Sueyoshi & Goto (2019)	√												
Ecer (2019)					√						√		
Korzeb & Samaniego-Medina (2019)		√											
Yalçın & Karakaş (2019)								√				√	
Aksoylu & Taşdemir (2020)		√											
Aktaş & Demirel (2021)		√	√								√		
Rao (2021)						√			√				
Guan & Zhao (2022)		√											√
Kahraman Ak & Türedi (2022)		√											

DEA: Data Envelopment Analysis; **TOPSIS:** Technique for Order Preference by Similarity to Ideal Solution; **VIKOR**: VIseKriterijumska Optimizacija Kompromisno Resenje; **MAUT:** Multi-Attribute Utility Theory; **ARAS:** A New Additive Ratio Assessment; **ANP:** Analytical Network Process; **GRA:** Grey Relational Analysis; **EDAS:** Evaluation Based On Distance From Average Solution; **DEMATEL:** Decision Making Trial and Evaluation Laboratory; **COPRAS:** Complex Proportional Assessment; **CRITIC:** The Criteria İmportance Through İntercriteria Correlation; **AHP:** Analytical Hierarchy Process

4. Material and Method

4.1. Data and Evaluation Criteria

The aim of this study is to evaluate the corporate sustainability performance of manufacturing companies included in the BIST Sustainability Index. For this purpose, the MEREC method, which is an objective weight assignment method among the MCDM methods, was used to weight the selected criteria, and then the companies were ranked using the CoCoSo method. Sustainability reports of the companies were obtained from their websites. Since the data for the majority of the companies were available for the year 2020, the evaluation was conducted based on the 2020 data. Due to variations in the shared data among the companies, 14 companies sharing common data were included in the analysis. The companies included in the analysis are shown in Table 2.

Table 2. Companies Evaluated for Corporate Sustainability Performance

No	Abbreviation	Company Title
1	**AKSA**	AKSA AKRİLİK KİMYA SANAYİİ A.Ş.
2	**AEFES**	ANADOLU EFES BİRACILIK VE MALT SANAYİİ A.Ş.
3	**AYGAZ**	AYGAZ A.Ş.
4	**CCOLA**	COCA-COLA İÇECEK A.Ş.
5	**FROTO**	FORD OTOMOTİV SANAYİ A.Ş.
6	**KARSN**	KARSAN OTOMOTİV SANAYİİ VE TİCARET A.Ş.
7	**KERVT**	KEREVİTAŞ GIDA SANAYİ VE TİCARET A.Ş.
8	**KORDS**	KORDSA TEKNİK TEKSTİL A.Ş.
9	**OTKAR**	OTOKAR OTOMOTİV VE SAVUNMA SANAYİ A.Ş.
10	**PETKM**	PETKİM PETROKİMYA HOLDİNG A.Ş.
11	**TOASO**	TOFAŞ TÜRK OTOMOBİL FABRİKASI A.Ş.
12	**TUPRS**	TÜPRAŞ-TÜRKİYE PETROL RAFİNERİLERİ A.Ş.
13	**TTRAK**	TÜRK TRAKTÖR VE ZİRAAT MAKİNELERİ A.Ş.
14	**ULKER**	ÜLKER BİSKÜVİ SANAYİ A.Ş.

One of the most critical processes in the use of MCDM methods is the selection of evaluation criteria. Errors in criteria selection or usage directly affect the evaluation results. The two most used methods for criteria selection are obtaining information from experts and selecting criteria commonly used in the literature. Since there is extensive literature on corporate sustainability performance, the study continued by selecting the most used criteria in the literature. The 11 criteria used in the study, their directions, and the studies in which they were used in the literature are shown in Table 3.

Table 3. Criteria Used in the Studies

Criteria	Abbreviation	Aspect	Description	Explanations	Source
Environmental	**C_1**	**Min**	**Greenhouse Gas Emission (Total Tons)**	The amount of greenhouse gas produced as a result of the activities of the companies	Khan et al. (2011), Sobhani et al. (2012), Öztel et al. (2012), Özçelik & Avcı Öztürk (2014), Alp et al. (2015), Medel-Gonzalez et al. (2015), Acar et al. (2015), Öztel et al. (2018), Ecer (2019), Yalçın & Karakaş (2019), Aksoylu & Taşdemir (2020), Aktaş & Demirel (2021)

Table 3. Criteria Used in the Studies (Continue)

Criteria	Abbreviation	Aspect	Description	Explanations	Source
Environmental	C_2	Min	**Water Consumption (Total m^3)**	The amount of clean and reuse water used by the companies in their activities	Khan et al. (2011), Öztel et al. (2012), Özçelik & Avcı Öztürk (2014), Acar et al. (2015), Alp et al. (2015), Medel-Gonzalez et al. (2015), Öztel et al. (2018), Yalçın & Karakaş (2019)
	C_3	Min	**Energy Consumption (Total Mwh)**	The amount of energy used by the companies in their activities	Khan et al. (2011), Sobhani et al. (2012), Öztel et al. (2012), Özçelik & Avcı Öztürk (2014), Acar et al. (2015), Alp et al. (2015), Medel-Gonzalez et al. (2015), Öztel et al. (2018), Sofyalıoğlu & Sürücü (2018), Ecer (2019), Yalçın & Karakaş (2019)
	C_4	Max	**Recycled Waste Rate (%)**	Percentage of recyclable waste in the waste of the companies	Öztel et al. (2012), Öztel et al. (2018), Yalçın & Karakaş (2019), Aksoylu & Taşdemir (2020), Aktaş & Demirel (2021)
	C_5	Max	**Reused Water Ratio (%)**	Percentage of reused water in the water used by the companies in their operations	Ecer (2019), Aksoylu & Taşdemir (2020)
Social	C_6	Max	**Ratio of Female Employees (%)**	Percentage of female employees in total employees	Öztel et al. (2012), Rebai et al. (2016), Öztel et al. (2018), Sofyalıoğlu & Sürücü (2018), Yalçın & Karakaş (2019), Aksoylu & Taşdemir (2020), Aktaş & Demirel (2021)
	C_7	Max	**Training Hours Per Employee**	Training hours per employee (on-the-job training / job security training / theoretical training)	Khan et al. (2011), Özçelik & Avcı Öztürk (2014), Medel-Gonzalez et al. (2015), Öztel et al. (2018), Yalçın & Karakaş (2019), Ecer (2019), Aksoylu & Taşdemir (2020), Aktaş & Demirel (2021)
	C_8	Min	**Personnel Turnover Rate**	The ratio of employees leaving the job to the average number of employees	Khan et al. (2011), Özçelik & Avcı Öztürk (2014), Öztel et al. (2018), Sofyalıoğlu & Sürücü (2018), Yalçın & Karakaş (2019), Ecer (2019), Aktaş & Demirel (2021)
Economical	C_9	Max	**Return on Assets (%)**	Ratio of total net profit to average assets	Özçelik & Avcı Öztürk (2014), Rebai et al. (2016), Yalçın & Karakaş (2019), Ecer (2019), Aksoylu & Taşdemir (2020)
	C_{10}	Max	**Operating Profit Margin (%)**	Ratio of operating profit to net sales	Alp et al. (2015), Öztel et al. (2018), Yalçın & Karakaş (2019), Aktaş & Demirel (2021)
	C_{11}	Max	**Return on Equity (%)**	Ratio of total net profit to average equity	Özçelik & Avcı Öztürk (2014), Rebai et al. (2016), Öztel et al. (2018), Yalçın & Karakaş (2019), Ecer (2019)

The values for the selected evaluation criteria are provided in Appendix 1. Information is provided about the solution procedures of the MEREC method used to weight the criteria and the CoCoSo method used to rank the companies.

4.2. MEREC

The MEREC method is one of the objectives (not requiring expert opinion) weight assignment methods introduced to the literature by Keshavarz-Ghorabaee et al. (2021). MEREC uses the removal effects of each criterion on the performance of alternatives to determine the criterion weights. In other words, when calculating the weight for a criterion, that criterion is disabled, and changes in the total criterion weights are observed. This feature distinguishes MEREC from other objective weight assignment methods such as CRITIC, Entropy, CILOS, and IDOCRIW. Due to its easily understandable and applicable solution algorithm, MEREC has become a preferred new MCDM method by data analysts. The method consists of six steps in its solution algorithm. These steps (Keshavarz-Ghorabaee et al., 2021: 8-9; Ayçin & Arsu, 2021: 78-79; Ersoy, 2022: 1045-1046) are as follows:

Step 1: Formation of the decision matrix

As with all MCDM methods, the solution procedure starts with the creation of the decision matrix. The decision matrix consisting of *m* alternatives and *n* criteria, showing the values of the *i*th alternative according to the *j*th criterion, is shown in Eq. (1).

$$\mathrm{X} = \begin{bmatrix} x_{11} & x_{12} & \cdots & x_{1j} & \cdots & x_{1n} \\ x_{21} & x_{22} & \cdots & x_{2j} & \cdots & x_{2n} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{i1} & x_{i2} & \cdots & x_{ij} & \cdots & x_{im} \\ \vdots & \vdots & \ddots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & \cdots & x_{mj} & \cdots & x_{mn} \end{bmatrix} \tag{1}$$

The values in the decision matrix (x_{ij}) should be positive (greater than 0). If a negative value exists in the decision matrix, it should be transformed into a positive value using an appropriate method.

Step 2: Normalization of the decision matrix

In this step, a simple linear normalization is used to scale the elements of the decision matrix. Elements of the normalized matrix are denoted by n_{ij}.

$$n_{ij} = \begin{cases} \dfrac{\min\limits_{k} x_{kj}}{x_{ij}}, & j \in \mathrm{B} \\ \dfrac{x_{ij}}{\max\limits_{k} x_{kj}}, & j \in \mathrm{C} \end{cases} \tag{2}$$

In Eq. (2), the benefit-oriented (max) criteria are represented by B, and the cost-oriented (min) criteria are represented by C.

Step 3: Calculation of general performance values of alternatives ($\mathbf{S_i}$)

To obtain the general performance of alternatives using equal criterion weights, a logarithmic measure based on a non-linear function is calculated using Eq. (3).

$$S_i = ln\left(1 + \left(\frac{1}{n}\sum_{j}\left|\ln\left(n_{ij}\right)\right|\right)\right) \tag{3}$$

Step 4. Calculation of general performance values of alternatives $\left(\boldsymbol{S'_{ij}}\right)$ by discarding the value of each criterion.

In this step uses a logarithmic criterion similar to step three. The difference between Step 4 and Step 3 is that the performances of the alternatives are calculated based on the discarding of each criterion separately. S'_{ij} values are calculated using Eq. (4).

$$S'_{ij} = ln\left(1+\left(\frac{1}{n}\sum_{k,k\neq j}\left|\ln\left(n_{ij}\right)\right|\right)\right) \tag{4}$$

Step 5: Calculation the sum of absolute deviations ($\boldsymbol{E_j}$)

In this step, the discarding effect of the j^{th} criterion is calculated based on the values obtained from Step 3 and Step 4. E_j shows the effect of discarding the j^{th} criterion. E_j values are calculated using Eq. (5).

$$E_j = \sum_i \left|S'_{ij} - S_i\right| \tag{5}$$

Step 6: Calculation of importance weights of the criteria

In the final step, the objective weight of each criterion is calculated using the discarding effects (E_j) of Step 5. The w_j in Eq. (6) represents the weight of the j^{th} criterion. Eq. (6) is used to calculate w_j.

$$w_j = \frac{E_j}{\sum_k E_k} \tag{6}$$

4.3. CoCoSo

The CoCoSo (Combining Compromise and Consensus Solution) method, proposed by Yazdani et al. (2019), is used to rank the alternatives (in this case, the manufacturing companies) based on their performance values. The method provides a comprehensive ranking by combining the concepts of compromise and consensus. The CoCoSo method, like all other MCDM methods, starts with the creation of the decision matrix. Since the same decision matrix was used in the first step of the MEREC method, the decision matrix is not given again here. The CoCoSo method has a solution procedure consisting of five steps (Yazdani et al., 2019; Khan & Haleem, 2021; Çilek, 2022).

Step 2: Normalization of the decision matrix

Compromise normalization equations were used for the normalization process of the criterion values. Eq. (7) is used for benefit-oriented (max) criteria and Eq. (8) is used for cost-oriented (min) criteria.

$$r_{ij} = \frac{x_{ij} - \min\limits_i x_{ij}}{\operatorname{maks}\limits_i x_{ij} - \min\limits_i x_{ij}} \tag{7}$$

$$r_{ij} = \frac{\operatorname{maks}\limits_i x_{ij} - x_{ij}}{\operatorname{maks}\limits_i x_{ij} - \min\limits_i x_{ij}} \tag{8}$$

Step 3: Calculation of (T_i) and (P_i) values

In the third step, the total of the weighted comparability sequence (T_i) is calculated using Eq. (9), the whole of the power weight of comparability sequences (P_i) is calculated using Eq. (10)

$$T_i = \sum_{j=1}^{n} (w_j r_{ij}) \tag{9}$$

$$P_i = \sum_{j=1}^{n} (r_{ij})^{w_j} \tag{10}$$

Step 4: Calculation of Triple Evaluation Scores

In the fourth step of the method, triple evaluation scores are calculated using Eq. (11-13).

$$\mathcal{k}_{ia} = \frac{P_i + S_i}{\sum_{i=1}^{m}(P_i + S_i)} \tag{11}$$

$$\mathcal{k}_{ib} = \frac{S_i}{\min\limits_i S_i} + \frac{P_i}{\min\limits_i P_i} \tag{12}$$

$$\mathcal{k}_{ic} = \frac{\lambda(S_i) + (1-\lambda)(P_i)}{\left(\lambda \operatorname{maks}\limits_i S_i + (1-\lambda) \operatorname{maks}\limits_i P_i\right)}, \quad 0 \le \lambda \le 1 \tag{13}$$

Eq. (11) expresses the arithmetic mean of the sums of the weighted sum method (WSM) and weighted product method (WPM) scores. Eq. (12) represents the sum of the relative scores of WSM and WPM according to the best. Finally, Eq. (13) also reflects the balanced reconciliation of the WSM and WPM model scores. Although λ in Eq. (13) is determined by the decision maker, it is generally used as 0.5 in the literature.

Step 5: Ranking of Decision Alternatives

In the last step, decision alternatives are ranked using Eq. (14). Decision alternatives are ranked on the condition that the alternative with the lowest $\mathcal{k}_i$ value is in the last rank, and the alternative with the highest $\mathcal{k}_i$ value is in the first rank.

$$\mathcal{k}_i = (\mathcal{k}_{ia} + \mathcal{k}_{ib} + \mathcal{k}_{ic})^{\frac{1}{3}} + \frac{1}{3}(\mathcal{k}_{ia}\mathcal{k}_{ib}\mathcal{k}_{ic}) \tag{14}$$

5. Findings

The MEREC and CoCoSo methods were used to evaluate the corporate sustainability performance of the companies included in the BIST sustainability index. Both MEREC and CoCoSo methods involve logarithmic and fractional calculations, so the values in the decision matrix should consist of positive numbers. However, the ratios of "return on assets," "operating profit margin", and "return on equity" in the decision matrix were calculated as negative for some companies. To convert these negative values into positive ones, the Z-score standardization transformation developed by Zhang et al. (2014) was used. The negative ratios in the decision matrix were transformed into positive values using Eq. (15) and (16).

$$z_{ij} = \frac{x_{ij} - \bar{X}_j}{\sigma_j} \tag{15}$$

$$z'_{ij} = z_{ij} + A; \qquad A > \left|\min z_{ij}\right| \tag{16}$$

The transformed initial decision matrix is presented in Table 4. This transformed decision matrix was used in the first step of both the MEREC and CoCoSo methods.

Table 4. Transformed Initial Decision Matrix

Companies	Environmental					Social			Economical		
	Min	Min	Min	Max	Max	Max	Max	Min	Max	Max	Max
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
AKSA	968910	4818912	3238193	0.438	23	11	17.4	0.050	1.982	2.562	1.814
AEFES	330839	14808766	1484831	0.899	1.26	29.9	13.06	0.108	1.055	1.355	1.088
AYGAZ	11986	88823	57675	0.999	20.44	14	20.82	0.048	0.545	0.467	0.807
CCOLA	651023	4148755	232138	0.042	1	17.4	10.05	0.074	1.665	1.929	1.465
FROTO	112483.2	998584	620827	0.998	11.35	17.55	53.4	0.053	3.251	1.301	3.283
KARSN	6467	36913	16838	1.000	57	5.4	13.4	0.039	0.732	4.065	0.967
KERVT	113351.6	2192625	345660	0.046	1.9	36.4	11.2	0.457	2.547	1.560	2.107
KORDS	1510713	2900376	490176	0.712	6.3	13.4	55.9	0.093	0.918	1.149	1.038
OTKAR	11495	183907	43384	0.844	81.8	5.3	5.12	0.045	2.798	2.775	3.358
PETKM	1962709	20580000	10050277	0.538	65.5	6.1	39.18	0.045	1.435	1.600	1.429
TOASO	103212	788444	275955	1.000	100	9.7	26.2	0.124	2.017	1.186	2.481
TUPRS	39608	23800000	24009444	0.588	63.6	9.6	17	0.033	0.009	0.003	0.003
TTRAK	31488	118401	29482	1.000	21.9	9.5	21.2	0.051	3.202	1.939	3.051
ULKER	137896	709083	442112	0.904	30	20.5	24.8	0.057	1.644	2.049	1.610

The transformed decision matrix in Table 4 was used to obtain the MEREC normalized decision matrix using Eq. (2). The normalized decision matrix is shown in Table 5.

Table 5. MEREC Normalized Decision Matrix

Companies	Environmental					Social			Economical		
	Min	Min	Min	Max	Max	Max	Max	Min	Max	Max	Max
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
AKSA	0.4937	0.2025	0.1349	0.0956	0.0435	0.4818	0.2943	0.1101	0.0046	0.0011	0.0015
AEFES	0.1686	0.6222	0.0618	0.0465	0.7937	0.1773	0.3920	0.2360	0.0086	0.0022	0.0025
AYGAZ	0.0061	0.0037	0.0024	0.0419	0.0489	0.3786	0.2459	0.1040	0.0167	0.0063	0.0033
CCOLA	0.3317	0.1743	0.0097	1.0000	1.0000	0.3046	0.5095	0.1626	0.0054	0.0015	0.0018
FROTO	0.0573	0.0420	0.0259	0.0419	0.0881	0.3020	0.0959	0.1154	0.0028	0.0023	0.0008
KARSN	0.0033	0.0016	0.0007	0.0418	0.0175	0.9815	0.3821	0.0847	0.0124	0.0007	0.0028
KERVT	0.0578	0.0921	0.0144	0.9084	0.5263	0.1456	0.4571	1.0000	0.0036	0.0019	0.0013
KORDS	0.7697	0.1219	0.0204	0.0588	0.1587	0.3955	0.0916	0.2033	0.0099	0.0026	0.0026
OTKAR	0.0059	0.0077	0.0018	0.0495	0.0122	1.0000	1.0000	0.0981	0.0032	0.0011	0.0008
PETKM	1.0000	0.8647	0.4186	0.0777	0.0153	0.8689	0.1307	0.0985	0.0063	0.0018	0.0019
TOASO	0.0526	0.0331	0.0115	0.0418	0.0100	0.5464	0.1954	0.2714	0.0045	0.0025	0.0011
TUPRS	0.0202	1.0000	1.0000	0.0711	0.0157	0.5521	0.3012	0.0715	1.0000	1.0000	1.0000
TTRAK	0.0160	0.0050	0.0012	0.0418	0.0457	0.5579	0.2415	0.1119	0.0028	0.0015	0.0009
ULKER	0.0703	0.0298	0.0184	0.0462	0.0333	0.2585	0.2065	0.1243	0.0055	0.0014	0.0017

Using the elements in the normalized decision matrix, the overall performance values (S_i) for each decision alternative were calculated using Eq. (3) and presented in Table 6. In addition, the overall performance values of the alternatives by discarding the value of each criterion (S'_{ij}) calculated using Eq. (4), the sum of absolute deviations (E_j) calculated using Eq. (5) and the importance weights of the criteria (w_j) calculated using Eq. (6) are also given in Table 6.

Table 6. Values of S_i, S'_{ij}, E_j, w_j and Total w_j

Companies	S_i	Environmental					Social			Economical		
		Min	Min	Min	Max	Max	Max	Max	Min	Max	Max	Max
		C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
AKSA	1.378	1.362	1.341	1.331	1.323	1.303	1.361	1.349	1.326	1.246	1.209	1.216
AEFES	1.300	1.255	1.288	1.228	1.221	1.294	1.256	1.276	1.263	1.174	1.135	1.138
AYGAZ	1.580	1.480	1.470	1.461	1.519	1.522	1.562	1.554	1.537	1.501	1.481	1.467
CCOLA	1.295	1.268	1.251	1.173	1.295	1.295	1.265	1.278	1.249	1.156	1.119	1.125
FROTO	1.535	1.478	1.471	1.461	1.471	1.487	1.512	1.489	1.492	1.413	1.408	1.385
KARSN	1.673	1.571	1.556	1.541	1.618	1.602	1.673	1.657	1.630	1.596	1.542	1.567
KERVT	1.352	1.282	1.294	1.247	1.350	1.337	1.305	1.333	1.352	1.210	1.192	1.181
KORDS	1.372	1.366	1.323	1.278	1.305	1.329	1.351	1.316	1.335	1.260	1.224	1.225
OTKAR	1.641	1.546	1.552	1.523	1.587	1.560	1.641	1.641	1.599	1.535	1.513	1.507
PETKM	1.313	1.313	1.310	1.292	1.249	1.205	1.310	1.262	1.255	1.181	1.146	1.146
TOASO	1.541	1.482	1.473	1.450	1.478	1.447	1.530	1.509	1.516	1.430	1.417	1.399
TUPRS	0.865	0.703	0.865	0.865	0.759	0.692	0.842	0.818	0.759	0.865	0.865	0.865
TTRAK	1.645	1.570	1.547	1.520	1.588	1.589	1.635	1.620	1.606	1.536	1.524	1.513
ULKER	1.530	1.476	1.458	1.448	1.468	1.461	1.503	1.499	1.488	1.422	1.392	1.395
E_j		0.870	0.824	1.204	0.794	0.898	0.277	0.421	0.615	1.497	1.855	1.892
w_j		0.078	0.074	0.108	0.071	0.081	0.025	0.038	0.055	0.134	0.166	0.170
Total (w_j)				0.412				0.118			0.47	
Rank		6	7	4	8	5	11	10	9	3	2	1

According to the weights obtained using the MEREC method, economic criteria have the highest weights, followed by environmental and social criteria. Accordingly, the most important criteria are "return on equity", "operating profit margin", and "return on assets", while the least important criteria are "employee turnover rate", "training hours per employee", and "female employee ratio".

Using the weights obtained through the MEREC method, the CoCoSo method was applied to rank the companies. Firstly, by applying the compromise normalization process described in Eq. (7) and (8) to the criterion values in the transformed decision matrix in Table 4, the normalized decision matrix shown in Table 7 was obtained.

Table 7. CoCoSo Normalized Decision Matrix

Companies	Environmental					Social			Economical		
	Min	Min	Min	Max	Max	Max	Max	Min	Max	Max	Max
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
AKSA	0.508	0.799	0.866	0.413	0.222	0.183	0.242	0.958	0.608	0.630	0.540
AEFES	0.834	0.378	0.939	0.895	0.003	0.791	0.156	0.823	0.323	0.333	0.323
AYGAZ	0.997	0.998	0.998	0.998	0.196	0.280	0.309	0.965	0.165	0.114	0.240
CCOLA	0.671	0.827	0.991	0.000	0.000	0.389	0.097	0.902	0.511	0.474	0.436
FROTO	0.946	0.960	0.975	0.998	0.105	0.394	0.951	0.953	1.000	0.320	0.978
KARSN	1.000	1.000	1.000	1.000	0.566	0.003	0.163	0.986	0.223	1.000	0.287
KERVT	0.945	0.909	0.986	0.004	0.009	1.000	0.120	0.000	0.783	0.383	0.627
KORDS	0.231	0.879	0.980	0.699	0.054	0.260	1.000	0.858	0.280	0.282	0.309
OTKAR	0.997	0.994	0.999	0.837	0.816	0.000	0.000	0.971	0.860	0.682	1.000
PETKM	0.000	0.136	0.582	0.518	0.652	0.026	0.671	0.971	0.440	0.393	0.425
TOASO	0.951	0.968	0.989	1.000	1.000	0.141	0.415	0.785	0.619	0.291	0.739
TUPRS	0.983	0.000	0.000	0.570	0.632	0.138	0.234	1.000	0.000	0.000	0.000
TTRAK	0.987	0.997	0.999	1.000	0.211	0.135	0.317	0.956	0.985	0.477	0.909
ULKER	0.933	0.972	0.982	0.900	0.293	0.489	0.388	0.943	0.504	0.504	0.479

The normalized criterion values in Table 7 and the MEREC weights were used to calculate the total values of the weighted comparable sequences (T_i) and the total values of the power weights of the comparable sequences (P_i) using Eq. (9) and (10). These values are presented in Tables 8 and 9.

Table 8. T_i Values

Companies	Environmental					Social			Economical			T_i
	Min	Min	Min	Max	Max	Max	Max	Min	Max	Max	Max	
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	
AKSA	0.040	0.059	0.094	0.029	0.018	0.005	0.009	0.053	0.082	0.105	0.092	0.584
AEFES	0.065	0.028	0.101	0.064	0.000	0.020	0.006	0.045	0.043	0.055	0.055	0.483
AYGAZ	0.078	0.074	0.108	0.071	0.016	0.007	0.012	0.053	0.022	0.019	0.041	0.500
CCOLA	0.052	0.061	0.107	0.000	0.000	0.010	0.004	0.050	0.069	0.079	0.074	0.505
FROTO	0.074	0.071	0.105	0.071	0.008	0.010	0.036	0.053	0.134	0.053	0.166	0.781
KARSN	0.078	0.074	0.108	0.071	0.046	0.000	0.006	0.054	0.030	0.166	0.049	0.683
KERVT	0.074	0.067	0.107	0.000	0.001	0.025	0.005	0.000	0.105	0.064	0.106	0.553
KORDS	0.018	0.065	0.106	0.050	0.004	0.006	0.038	0.047	0.038	0.047	0.052	0.472
OTKAR	0.078	0.073	0.108	0.060	0.066	0.000	0.000	0.054	0.116	0.114	0.170	0.837
PETKM	0.000	0.010	0.063	0.037	0.052	0.001	0.025	0.054	0.059	0.065	0.072	0.439
TOASO	0.074	0.072	0.107	0.071	0.081	0.004	0.016	0.043	0.083	0.048	0.125	0.724
TUPRS	0.077	0.000	0.000	0.041	0.051	0.003	0.009	0.055	0.000	0.000	0.000	0.236
TTRAK	0.077	0.074	0.108	0.071	0.017	0.003	0.012	0.053	0.132	0.079	0.154	0.781
ULKER	0.073	0.072	0.106	0.064	0.024	0.012	0.015	0.052	0.068	0.084	0.081	0.650

Table 9. P_i Values

Companies	Environmental						Social		Economical			P_i
	Min	Min	Min	Max	Max	Max	Max	Min	Max	Max	Max	
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}	
AKSA	0.949	0.984	0.985	0.939	0.886	0.959	0.948	0.998	0.935	0.926	0.901	10.408
AEFES	0.986	0.931	0.993	0.992	0.620	0.994	0.932	0.989	0.859	0.833	0.826	9.955
AYGAZ	1.000	1.000	1.000	1.000	0.877	0.969	0.957	0.998	0.785	0.697	0.785	10.067
CCOLA	0.969	0.986	0.999	0.000	0.000	0.977	0.916	0.994	0.914	0.883	0.869	8.507
FROTO	0.996	0.997	0.997	1.000	0.834	0.977	0.998	0.997	1.000	0.827	0.996	10.619
KARSN	1.000	1.000	1.000	1.000	0.955	0.867	0.934	0.999	0.817	1.000	0.809	10.382
KERVT	0.996	0.993	0.999	0.679	0.685	1.000	0.923	0.000	0.968	0.853	0.924	9.018
KORDS	0.892	0.991	0.998	0.975	0.790	0.967	1.000	0.992	0.843	0.810	0.819	10.076
OTKAR	1.000	1.000	1.000	0.987	0.984	0.000	0.000	0.998	0.980	0.938	1.000	8.887
PETKM	0.000	0.863	0.943	0.954	0.966	0.913	0.985	0.998	0.896	0.856	0.865	9.239
TOASO	0.996	0.998	0.999	1.000	1.000	0.953	0.967	0.987	0.938	0.814	0.950	10.601
TUPRS	0.999	0.000	0.000	0.961	0.964	0.952	0.947	1.000	0.000	0.000	0.000	5.822
TTRAK	0.999	1.000	1.000	1.000	0.882	0.952	0.957	0.998	0.998	0.884	0.984	10.653
ULKER	0.995	0.998	0.998	0.993	0.906	0.982	0.965	0.997	0.912	0.892	0.883	10.520

In order to reach the relative performance values ($\mathcal{k}_i$) of the alternatives in the last step and the rankings of the companies, firstly, the triple evaluation scores called $\mathcal{k}_{ia}$, $\mathcal{k}_{ib}$ and $\mathcal{k}_{ic}$ were calculated. The λ value is used as 0.5. The values calculated using Eq. (11-14) and the companies rankings are shown in Table 10.

Table 10. Triple Evaluation Scores and Rankings

	$\mathcal{k}_{ia}$	$\mathcal{k}_{ib}$	$\mathcal{k}_{ic}$	$\mathcal{k}_i$	**Ranking**
AKSA	0.0768766	4.266367	0.956623	1.8480843	7
AEFES	0.0730008	3.7590338	0.9083944	1.7629495	9
AYGAZ	0.073903	3.8507127	0.9196215	1.7792667	8
CCOLA	0.0630273	3.6039487	0.7842875	1.7043647	12
FROTO	0.0797355	5.138911	0.9921979	1.9736798	2
KARSN	0.0773842	4.6789007	0.9629396	1.9045401	5
KERVT	0.0669426	3.8964476	0.8330081	1.7588701	11
KORDS	0.073769	3.731476	0.9179541	1.7620478	10
OTKAR	0.0680105	5.0776014	0.8462965	1.9137206	4
PETKM	0.0676864	3.4474723	0.8422636	1.698853	13
TOASO	0.0792072	4.8923517	0.9856249	1.940101	3
TUPRS	0.0423658	2	0.5271843	1.3845695	14
TTRAK	0.0799696	5.1426655	0.9951118	1.9752573	1
ULKER	0.0781215	4.5651788	0.9721147	1.8930005	6

According to the criteria selected as a result of the CoCoSo method, the companies with the best corporate sustainability performance are Türk Traktör, Ford, and Tofaş, while the companies with the lowest corporate sustainability performance are Coca Cola, Petkim, and Tüpraş.

6. Results and Discussion

In the research firstly, the criteria determined based on the literature review were weighted using the MEREC method. According to the weights obtained through the MEREC method, the most important criteria were "return on equity", "operating profit margin", and "return on assets", while the least important criteria were "employee turnover rate", "training hours per employee", and "female employee ratio". Economic criteria had the highest total weight (0.47), followed by environmental criteria (0.412), and social criteria (0.118). In studies conducted by Ecer (2019) and Sofyalıoğlu & Sürücü (2018) the highest weights were attributed to social, environmental, and economic criteria, respectively. Ecer (2019) assessed the corporate sustainability performance of deposit banks, while Sofyalıoğlu & Sürücü (2018) evaluated the performance of home appliance companies. The differing ranking found in this study is believed to stem from sector-specific differences. Similarly, in a study by Goyal et al. (2015) that assessed the corporate sustainability performance of the manufacturing sector, economic criteria were found to be the most important criterion group, followed by environmental and social criteria. The findings which are parallel with Goyal et al. (2015) confirm the hypothesis that the difference in weights arises from sector-specific variations.

The weights obtained through the MEREC method were used in CoCoSo to rank the manufacturing companies based on their corporate sustainability performance. According to the rankings, Türk Traktör, Ford, Tofaş, and Otokar were the companies with the highest corporate sustainability performance, while Kerevitaş, Coca Cola, Petkim, and Tüpraş were the companies with the lowest corporate sustainability performance. The finding that high-performing companies are predominantly automotive companies supports the findings of Aksoylu & Taşdemir (2020). According to their study, automotive companies exhibited the highest performance in economic and environmental criteria, which are the most important criterion groups in this study.

Consistent results of MCDM solutions are of great importance for a healthy interpretation of the analysis. It is possible to come across various sensitivity analyzes in MCDM applications. In this study, the solution was repeated with the GRA (Grey Relational Analysis), MABAC (The Multi-Attributive Border Approximation area Comparison), ARAS (A New Additive Ratio Assessment), TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) and WASPAS (Weighted Aggregated Sum Product Assessment) methods to test the consistency of the rankings obtained by the CoCoSo method using MEREC weights. The Spearman's rank correlation values between the rankings obtained from different MCDM methods and the rankings obtained using the CoCoSo method are presented in Table 11.

Table 11. Rankings Obtained by Different MCDM methods and Spearman's Rank Correlations

Methods/ Companies	CoCoSo	GRA	MABAC	ARAS	TOPSIS	WASPAS
AKSA	7	9	7	8	7	8
ANADOLU	9	12	11	13	11	13
AYGAZ	8	7	10	6	10	7
COCACOLA	12	10	9	11	9	11
FORD	2	2	2	4	3	4
KARSAN	5	4	5	1	4	2
KERVİTAŞ	11	8	8	10	8	9
KORDSA	10	11	12	12	12	12
OTOKAR	4	1	1	2	1	1
PETKİM	13	13	13	9	13	10

Table 11. Rankings Obtained by Different MCDM methods and Spearman's Rank Correlations (Continue)

Methods/ Companies	CoCoSo	GRA	MABAC	ARAS	TOPSIS	WASPAS
TOFAŞ	3	5	4	5	5	5
TÜPRAŞ	14	14	14	14	14	14
TÜRK TRAKTÖR	1	3	3	3	2	3
ÜLKER	6	6	6	7	6	6
CoCoSo vs. Spearman's Rho Values		0.899**	0.903**	0.833**	0.899**	0.855**

** Correlation value at 0.01 significance level

Significant correlation values were found between the rankings obtained through the CoCoSo method and the rankings obtained through other MCDM methods. The high correlation values demonstrate the consistency of the rankings obtained using the CoCoSo method.

7. Conclusion, Limitations, and Recommendations

Corporate sustainability has become one of the key areas that companies have been focusing on and investing heavily in recent years. Initially perceived as a burden, corporate sustainability has proven to bring both social and financial benefits to organizations. Especially the improvement in environmental performance indicators also provides huge monetary contributions to the companies. Systems implemented for water reuse have reduced water costs, while waste disposal systems for energy recovery have significantly decreased energy costs. Over time, these and similar financial benefits have further encouraged companies to enhance their corporate sustainability performance. Thus, this study aims to assess the corporate sustainability performance of manufacturing firms using the MCDM methods.

When the results examined, the high performance of automotive companies is believed to be attributed to their high profitability figures, while the low performance of petrochemical companies may be due to low profitability and high water and energy consumption. Considering the significant weight assigned to economic criteria in this study, the poorly performing companies may improve their corporate sustainability performance by implementing measures to increase their profitability. Additionally, restricting water and energy consumption or implementing systems that promote water reuse and increase the share of renewable energy in their energy usage can contribute positively to corporate sustainability performance.

As with any research, this study has some limitations. The data used in this research were compiled from corporate sustainability reports shared by companies. Although these reports are not standard for every company, the sharing schedule also differs from company to company. Therefore, although more production companies are included in the corporate sustainability index, a small number of companies could be included in the analysis. In addition, since the most up-to-date data of the largest number of companies belongs to 2020, analysis could be made using the data in 2020.

The MEREC and CoCoSo methods used together in this study can be employed in future researches to evaluate the corporate sustainability performance of different sectors or assess different performance indicators such as financial performance, profitability, efficiency, and so on. One of the most important processes in the use of MCDM methods is the criterion selection process. In future studies, qualitative (observation, interview, etc.) or quantitative (survey, etc.) researches can be designed with the participation of sector representatives for the selection of criteria. As it is known, 2020 was a year when the effects of covid -19 were seen. More comprehensive results will be obtained with data free from the effects of the pandemic which has affected the world.

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Appendix

Appendix 1. Decision Matrix

Companies	Environmental					Social			Economical		
	Min	Min	Min	Max	Max	Max	Max	Min	Max	Max	Max
	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}	C_{11}
AKSA	968910	4818912	3238193	0.438	23	11	17.4	0.050	0.089	0.201	0.236
AEFES	330839	14808766	1484831	0.899	1.26	29.9	13.06	0.108	0.029	0.102	0.058
AYGAZ	11986	88823	57675	0.999	20.44	14	20.82	0.048	-0.005	0.028	-0.011
CCOLA	651023	4148755	232138	0.042	1	17.4	10.05	0.074	0.069	0.149	0.150
FROTO	112483.2	998584	620827	0.998	11.35	17.55	53.4	0.053	0.172	0.097	0.596
KARSN	6467	36913	16838	1.000	57	5.4	13.4	0.039	0.008	0.325	0.028
KERVT	113351.6	2192625	345660	0.046	1.9	36.4	11.2	0.457	0.126	0.118	0.308
KORDS	1510713	2900376	490176	0.712	6.3	13.4	55.9	0.093	0.020	0.085	0.046
OTKAR	11495	183907	43384	0.844	81.8	5.3	5.12	0.045	0.143	0.219	0.614
PETKM	1962709	20580000	10050277	0.538	65.5	6.1	39.18	0.045	0.054	0.122	0.142
TOASO	103212	788444	275955	1.000	100	9.7	26.2	0.124	0.092	0.088	0.399
TUPRS	39608	23800000	24009444	0.588	63.6	9.6	17	0.033	-0.040	-0.010	-0.208
TTRAK	31488	118401	29482	1.000	21.9	9.5	21.2	0.051	0.169	0.150	0.539
ULKER	137896	709083	442112	0.904	30	20.5	24.8	0.057	0.067	0.159	0.186

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