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DECISION-SUPPORT FRAMEWORK FOR MULTIDIMENSIONAL ESG PERFORMANCE EVALUATION IN THE BANKING SECTOR (*)

BANKACILIK SEKTÖRÜNDE ÇOK BOYUTLU ESG PERFORMANS DEĞERLENDİRMESİ İÇİN BİR KARAR DESTEK ÇERÇEVESİ

Onur KAYRAN [(1)], Murat KIYILAR [(2)]

Abstract: For financial institutions, sustainable development has become a priority concern for both the investors and the sector. This manuscript suggests a holistic decision-making approach for the sustainability evaluation of deposit banks by integrating the CRISUS, MSD, and AROMAN algorithms. Building on earlier research, this research uses a multi-criteria assessment framework encompassing three main dimensions (environmental, social, and governance) and 15 indicators within the scope of sustainability. Using this introduced model, the research conducts a holistic assessment of the ESG performance of eight Turkish commercial banks. The results reveal that environmental criteria – particularly total greenhouse gas emissions, renewable energy usage rate, and green loan rate – have the strongest impact on ESG performance, and Garanti BBVA demonstrates the highest performance among the analyzed banks. In conclusion, the hybrid approach introduced in this manuscript provides a robust and reliable decision support tool for implementers and decision makers for analyzing and improving the sustainable development strategies in banking.

Keywords: ESG Performance, Banking Industry, CRISUS, MSD, AROMAN, MCDM

JEL: *C54, G17, G21, G32, G53*

Öz: *Finans kuruluşları için sürdürülebilir kalkınma, hem sektör hem de yatırımcılar için öncelikli bir endişe kaynağı haline gelmiştir. Bu araştırma, CRISUS, MSD ve AROMAN algoritmalarını entegre ederek ticari bankaların sürdürülebilirlik değerlendirmesi için kapsamlı bir karar alma metodolojisi önermektedir. Daha önceki araştırmalara dayanarak, bu çalışma sürdürülebilirlik kapsamında üç ana boyutu (çevresel, sosyal ve yönetişim) ve 15 göstergeyi kapsayan çok kriterli bir değerlendirme çerçevesi oluşturmaktadır. Bu model kullanılarak, araştırma sekiz Türk ticari bankasının ESG sürdürülebilirlik performansının kapsamlı bir değerlendirmesini yapmaktadır. Sonuçlar, çevresel kriterlerin – özellikle toplam sera gazı emisyonları, yenilenebilir enerji kullanım oranı ve yeşil kredi oranı – ESG performansı üzerinde en güçlü etkiye sahip olduğunu ve Garanti BBVA'nın analiz edilen bankalar arasında en yüksek performansı gösterdiğini ortaya koymaktadır. Sonuç olarak, bu makalede sunulan hibrit yaklaşım, bankacılık sektöründe sürdürülebilir kalkınma stratejilerini analiz etmek ve geliştirmek için uygulayıcılar ve karar vericiler için sağlam ve güvenilir bir karar destek aracı sağlamaktadır.*

Anahtar Kelimeler: *Bankacılık Sektörü, ESG Performansı, ÇKKV, CRISUS, MSD, AROMAN*

[(1)] İstanbul Üniversitesi, İşletme Fakültesi, Finans Anabilim Dalı; onur.kayran@ogr.iu.istanbul.edu.tr, ORCID 0000-0003-3959-9404
[(2)] İstanbul Üniversitesi, İşletme Fakültesi, Finans Anabilim Dalı; muratkiy@istanbul.edu.tr, ORCID: 0000- 0001- 6972- 8700
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1. Introduction

Banks, which are among the most critical players in money and capital markets, especially in developing countries, provide vital financial services to savers and entities in need of funds. Banks also nourish the development and sustainable growth of economic sectors through their business models. However, due to the nature of banking transactions, characterized by high leverage, maturity conversion, and information asymmetries, they are exposed to high liquidity risk, credit risk, operational risk, and reputational risk. Therefore, bank performance assessments based solely on traditional financial metrics are inadequate to encounter the anticipations of different stakeholder groups (Işık et al., 2026). As a result, changing investor expectations, tightening prudential regulations, and growing public scrutiny require a multi-dimensional bank performance perspective that extends beyond traditional market and accounting-based indicators (McDonald & Lai, 2011).

In the context of this shifting paradigm, environmental, social, and governance (ESG) factors have become critical indicators affecting banks' risk profile, reputation, and capacity to create sustainable value. The transmission of environmental and climate-related risks into credit portfolios, the influence of social policies on human capital and stakeholder relations, and the role of governance arrangements in shaping corporate decision-making are now widely recognized as constitutive — rather than peripheral — elements of banks' sustainable performance (Manta et al., 2025). Against this backdrop, the regular, systematic, and comparable measurement of banks' ESG performance has become a strategic priority for managers seeking to allocate capital efficiently, investors pricing sustainability-related risks, and regulatory authorities monitoring financial stability (Karki et al., 2025).

Operationalizing ESG, however, is an inherently complex decision-making problem. The construct spans a large number of heterogeneous indicators that differ in their benefit/cost orientation, units of measurement, and underlying statistical distributions, and that must be evaluated jointly across the environmental, social, and governance pillars. Conventional single-dimensional analytical methods cannot accommodate this heterogeneity in a methodologically defensible manner and tend to obscure the trade-offs that lie at the heart of sustainability assessment (Kim & Li, 2021; Cohen, 2023). This challenge is particularly evident in the banking sector, where ESG performance has direct impacts on credit allocation, market valuation, and operational efficiency, and therefore requires analytically robust and flexible evaluation frameworks (López-Penabad et al., 2023; Dou et al., 2025).

Multi-Criteria Decision Making (MCDM) algorithms provide decision-makers and implementers with two fundamental pieces of information to overcome this problem (Işık et al., 2026). Firstly, these algorithms allow for the determination of weighting values for heterogeneous criteria within an analytical framework. Thus, decision-makers gain knowledge about the most critical criteria affecting sustainability performance. Secondly, they generate reliable and systematic ranking results by calculating directly comparable performance scores of decision alternatives, i.e., banks, based on ESG indicators (Tekgün, 2025; Dou et al., 2025).

In this context, the current manuscript suggests using a hybrid MCDM approach to gauge and compare the sustainability performance of banks based on their ESG indicators. Within the suggested hybrid methodology, the importance weights of the ESG indicators are computed based on the MSD and CRISUS algorithms. Then, the

weights calculated from these two weighting procedures are combined through a linear aggregation operator to find the balanced final weight coefficients. In the final stage, the AROMAN procedure is utilized to rank the performance of bank alternatives. The introduced decision approach is applied to a case study comparing the BIST-listed banks' ESG-based sustainability performance. Within this analytical framework, this manuscript seeks to response the following research questions:

- ✓ Why is the regular, systematic, and objective measurement of ESG performance important for decision-making in the banking sector?
- ✓ Which ESG metrics are most relevant for evaluating the ESG performance of commercial banks?
- ✓ Which criteria exert the strongest, and which the weakest, influence on banks' overall ESG performance?
- ✓ How do commercial banks listed on Borsa Istanbul rank relative to one another in terms of ESG performance?

Before describing these contributions, it is worth to highlight the specific limitations of the current approaches targeted by current work: (i) over-reliance on a single objective weighting technique that leaves criterion weights vulnerable to methodological bias; (ii) limited use of two-stage normalization capable of handling both benefit/cost type ESG metrics; and (iii) infrequent use of systematic sensitivity and rank reversal tests. The CRISUS–MSD–AROMAN combination is particularly well suited to address these issues: CRISUS and MSD are based on different statistical foundations, so their combination lessens the bias of any single weighting structure, while two-stage normalization in AROMAN procedure is designed for the mixed benefit/cost and usually skewed nature of banking ESG data.

Our manuscript offers four contributions to the existing banking literature on bank performance evaluation and sustainable finance. First, it proposes a novel integrated weighting procedure that combines CRISUS, a recently developed sum-of-squares-based discriminator, with MSD, a dispersion-sensitive measure of dispersion. Because the two methods are based on different statistical foundations, combining them reduces methodological bias that might arise from using a weighting procedure alone; this issue is particularly evident in banking data where indicator distributions are typically skewed and thick-tailed. Second, our study combines criterion weighting and alternative ranking in a single transparent analytical structure, ensuring that the contribution of each stage to the final scores remains fully traceable. Third, by using AROMAN, a two-stage normalization that is particularly effective in addressing the mix of benefit and cost criteria characterizing ESG indicators and which is still underutilized in ESG-based banking studies, this work expands the existing empirical methodological toolset for sustainability-focused bank performance evaluation. Fourth, by applying the framework to commercial banks listed on BIST, it provides a robust and stable analytical tool that bank managers can use for internal benchmarking, regulatory and supervisory authorities can use to monitor sustainability progress in the banking sector, and investors can use for sustainability-sensitive portfolio screening. In conclusion, these contributions provide theoretical, methodological, and managerial insights that advance the growing literature on ESG-based bank performance evaluation.

2. Literature Review

In the banking sector, performance evaluation has become one of the research areas where MCDM approaches are widely applied, owing to the multi-dimensional nature of bank performance and the often conflicting performance criteria. The case is particularly evident in ESG- and sustainability-oriented evaluations, where the heterogeneity of the criteria and the high degree of inter-bank differentiation jointly necessitate analytically robust weighting and ranking procedures.

One of the earliest studies in this strand was conducted by Abdel-Basset et al. (2021), who assessed the performance of commercial banks operating in the Egyptian banking sector by combining an AHP-based weighting method with TOPSIS, VIKOR, and COPRAS ranking procedures. Their analysis comparatively documented the impact of different ranking algorithms on the final scores and underscored the methodological sensitivity of the rankings. Likewise, Rao et al. (2021) weighted the performance indicators of 19 Indian banks based on the SD-CRITIC hybrid weighting methodology and produced the rankings of banks via the ARAS and MOORA approaches. Kumar and Sharma (2024) analyzed the performance of 9 banks operating in India with a hybrid CRITIC–TOPSIS methodology. In the Vietnamese banking industry, Nguyen et al. (2022) computed criterion weight coefficients with the aid of CRITIC and DEMATEL methods and obtained the bank rankings via TOPSIS.

The combination of fuzzy and grey logic procedures into banking performance analysis has also attracted considerable interest in the literature. Işık et al. (2025a) assessed the performance of 15 deposit banks operating in Pakistan using fuzzy LBWA and fuzzy LMAW procedures for weighting and the MARCOS method for ranking. In a related study, Işık et al. (2025b) evaluated the performance of Turkish Islamic banks through spherical fuzzy SWARA and SPC techniques and derived the rankings via the AROMAN approach. Işık et al. (2025c) weighted the performance criteria of seven BIST-listed deposit banks using grey MSD and grey SPC and obtained the rankings through the grey SRP method. Together, these studies illustrate the effectiveness of fuzzy and grey MCDM approaches in handling the uncertainty inherent in banking data.

The number of studies focusing on ESG- and sustainability-based banking performance has also grown in recent years. Ünlü et al. (2022) analyzed the performance of 12 Turkish deposit banks through SWARA II and MEREC weighting procedures and ranked them via the MARCOS technique. Mastilo et al. (2024) evaluated the performance of 21 banks operating in Bosnia and Herzegovina through a hybrid MEREC–MARCOS framework. Goel et al. (2024) gauged and assessed the performance of 10 Indian banks over the 2018–2023 period using an equal-weighting scheme and obtained the rankings via the Grey Incidence Analysis (GIA) technique.

ESG-focused studies in the Turkish context are particularly relevant for the present analysis. Tekgün (2025) weighted the ESG performance of banks listed on BIST using grey LOPCOW and grey MSD techniques and derived comparative rankings through the grey PIV approach. Karki et al. (2025) weighted the Indian banks' ESG performance via R-SWARA and ranked them through CoCoSo.

While MCDM algorithms are widely applied in the banking industry, studies concentrated on ESG and sustainability still exhibit significant methodological gaps. The literature has not yet reached sufficient methodological maturity in terms of weighting approaches, criterion structures, and ranking algorithms. While techniques

such as LOPCOW, SD, MAXC, MEREC, Entropy, and MPSI, are mostly applied, integrated hybrid frameworks combining objective weighting approaches based on diverse statistical foundations remain limited. This situation surges the risk of methodological sensitivity and weighting bias, especially in the banking industry. Therefore, In the hybrid weighting framework proposed in this research, integrating CRISUS and MSD weights can yield more unbiased and reliable criteria weights. Most importantly, there are three common limitations in these studies that this paper directly tackles: (1) most of the papers depend on a single objective weighting procedure (e.g., LOPCOW, SD, Entropy, or MEREC) and rarely cross-validate weights obtained by statistically different approaches, making weights sensitive to the idiosyncrasies of the selected approach; (2) the presence of benefit and cost-type ESG metrics is rarely addressed by a two-stage normalization framework; and (3) ranking outcomes are regularly presented without performing a systematic sensitivity or rank-reversal analysis, leaving their robustness largely untested.

On the other hand, while methodological diversity has increased in the weighting phase, the ranking phase has largely focused on TOPSIS, MARCOS, and CRADIS. Therefore, next-generation methods based on two-stage normalization—especially AROMAN—have only been applied to a limited extent in the banking and ESG context.

To address these gaps, the existing paper evaluates banks' ESG performance within a multidimensional criterion set and an integrated MCDM approach. In this context, objective weighting coefficients were first computed with the aid of the CRISUS and MSD procedures, and then the weighting values derived from these two methodologies were combined with a linear aggregation operator. This aims to reduce methodological bias when calculating optimal weighting values. Bank sustainability performance rankings are achieved according to the AROMAN tool, which is rarely applied in this field. This manuscript aims to contribute methodological diversity, analytical robustness, and a holistic perspective to the ESG-based performance measurement literature in the banking industry.

3. Research Methodology

Analyzing the ESG performance of institutions operating in the banking industry is a multi-dimensional decision-making problem. In this context, the present manuscript ranks banks by comparing their ESG performance using an integrated decision-making approach. In the analysis phase, the weighting coefficients of the criteria are first obtained from objective weighting techniques such as CRISUS and MSD. The weighting values obtained from the application of both procedures are combined based on a linear aggregation operator, and the resulting optimal weighting value is then included in the ranking phase to provide a comprehensive comparison of the banks' ESG performance. Lastly, the final rankings of alternative banks are calculated with the help of AROMAN procedure. The theoretical foundations and application steps of these methods are described below, and the overall structure of the introduced hybrid approach is displayed in Figure 1.

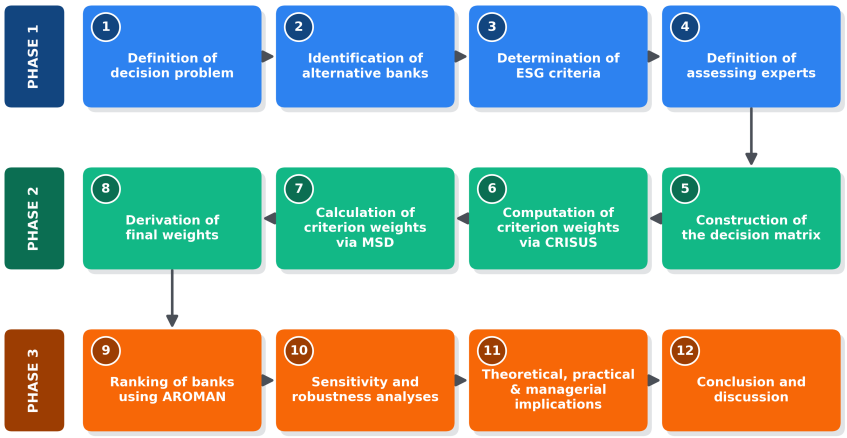


Figure 1. Proposed Combined Methodological Framework

3.1. CRISUS Procedure

The CRISUS procedure, introduced by Adalar and Işık (2025), objectively calculates the weights of the criteria using an analytical procedure based on the fundamental logic of the Entropy method (Shannon, 1948) and Statistical Variance technique (Rao & Patel, 2010), which are well-known in the MCDM literature. The calculation steps of the CRISUS procedure are given below.

Step 1. The performance matrix is formed according to Eq. (1).

$$\tilde{Y} = \left(\begin{bmatrix} \tilde{y}_{11} & \cdots & \tilde{y}_{1n} \\ \vdots & \ddots & \vdots \\ \tilde{y}_{m1} & \cdots & \tilde{y}_{mn} \end{bmatrix} \right) \tag{1}$$

Step 2. The first normalization of the elements in the performance matrix is carried out by applying Eq. (2) for beneficial criteria and Eq. (3) for non-beneficial criteria, respectively.

$$f_{ij} = \frac{\tilde{y}_{ij}}{\sqrt{\sum_{i=1}^{m} \tilde{y}_{ij}^2}} \tag{2}$$

$$f_{ij} = 1 - \frac{\tilde{y}_{ij}}{\sqrt{\sum_{i=1}^{m} \tilde{y}_{ij}^2}} \tag{3}$$

Step 3. The second normalization matrix is obtained by applying Eq. (4).

$$s_{ij} = \frac{f_{ij}}{\sum_{i=1}^{m} f_{ij}} \tag{4}$$

Step 4. The sum of squares associated with each criterion is obtained with the help of Eq. (5).

$$\rho_j = \sum_{i=1}^{m} s_{ij}^2 \tag{5}$$

Step 5. The standard deviation scores (σ_j) of the criteria in the first normalized matrix are identified.

$$\sigma_{\mathrm{j}} = \sqrt{\frac{\sum_{\mathrm{i=1}}^{\mathrm{m}} (\mathrm{f_{ij}} - \overline{f_j})^2}{\mathrm{m}}} \tag{6}$$

Step 6. The importance weight values of each performance criterion are computed according to Eq. (7).

$$w_j = \frac{\sigma_j \rho_j}{\sum_{j=1}^{n} \sigma_j \rho_j} \tag{7}$$

3.2. MSD Algorithm

Introduced by Puška et al. (2022), the MSD methodology is an objective weighting technique derived by extending the standard deviation-based weighting procedure, which is well-known in the decision-making literature. In the MCDM literature, MSD approach has been successfully applied to various decision problems, including the assessment of agricultural machinery (Puška et al., 2022), deposit banks' sustainability performance assessment (Akbulut & Aydın, 2024), and the year-by-year comparison of Türkiye's renewable energy performance (Durmuş, 2025). The MSD weighting procedure consists of six computational steps that enable the systematic and consistent derivation of criterion weights.

Step 1. The performance matrix given in Eq. (1) is formed.

Step 2. In this step, the initial decision matrix is normalized in terms of beneficial and non-beneficial criteria using Eqs. (8) and (9).

$$v_{ij} = \frac{\tilde{y}_{ij}}{max\{\tilde{y}_{ij} | i = 1,2,\dots,m\}} \tag{8}$$

$$v_{ij} = \frac{min\{\tilde{y}_{ij} | i = 1,2,\dots,m\}}{\tilde{y}_{ij}} \tag{9}$$

Step 3. The standard deviation values associated with each assessment criterion are computed in accordance with Eq. (10).

$$\sigma_j = \sqrt{\frac{\sum_{i=1}^{m} (v_{ij} - \overline{v_j})^2}{m}} \tag{10}$$

Step 4. Column-wise totals for the criteria are obtained.

Step 5. The adjusted values of the standard deviation measures are computed utilizing Eq. (11).

$$\sigma' = \frac{\sigma}{\sum_j^n y_{ij}} \tag{11}$$

Step 6. The objective importance weights of each criterion considered in the research were identified by applying Eq. (12).

$$w_j = \frac{\sigma_j'}{\sum_{j=1}^n \sigma_j'} \tag{12}$$

3.3. Final Weighting Procedure

In this section, the criterion weight coefficients computed by the CRISUS and MSD approaches are combined with a linear aggregation operator defined in Eq. (13) in order to obtain more unbiased, consistent and balanced weighting coefficients (Işık et al., 2024; Tekgün et al., 2026). Thanks to this integration structure, methodological biases and potential methodological biases that may arise from relying on a single objective weighting approach are minimized.

$$w_j^{(Final)} = \Psi w_j^{(CRISUS)} + (1 - \Psi) w_j^{(MSD)} \tag{13}$$

The parameter Ψ appearing in Eq. (13) denotes a fixed coefficient that takes values within the interval [0, 1]. Although, a review of the applicable literature shows that this coefficient is usually incorporated into the calculations with a value of 0.5.

3.4. AROMAN Method

The AROMAN, developed by Bošković et al. (2023), is an MCDM algorithm for ranking decision alternatives. Owing to its bidirectional (two-step) normalization structure, AROMAN constructs a balanced decision matrix that captures the average performance levels of the alternatives across all assessment criteria. Its analytical flexibility and computational simplicity have led to its successful application to a wide range of decision problems, including electric vehicle selection (Bošković et al., 2023), postal network optimization (Nikolić et al., 2023), the assessment of wastewater treatment plants (Alrasheedi et al., 2024), the analysis of sustainable propulsion technologies (Bošković et al., 2024), the evaluation of countries' green logistics performance (Özekenci, 2025), and the measurement of banks' efficiency, productivity, and sustainability performance (Işık et al., 2025b). The steps of the AROMAN sorting algorithm are given below.

Step 1. The performance matrix given in Eq. (1) is formed.

Step 2. The normalized values associated with the performance criteria in the decision matrix were determined to employing Eqs. (14) and (15). While Eq. (14) is employed for linear normalization, Eq. (15) is used for vector normalization.

Step 2.1. Linear Normalization

$$t_{ij} = \frac{\tilde{y}_{ij} - min(\tilde{y}_{ij})}{max(\tilde{y}_{ij}) - min(\tilde{y}_{ij})} \tag{14}$$

Step 2.2. Vector Normalization

$$t_{ij}^{*} = \frac{\tilde{y}_{ij}}{\sqrt{\sum_{i=1}^{m}(\tilde{y}_{ij})^2}} \tag{15}$$

Step 2.3. By applying linear and vector normalization procedures, the resulting matrix elements were converted into mean normalized values as specified in Eq. (16).

$$t_{ij}^{norm} = \frac{\beta t_{ij} + (1-\beta)t_{ij}^{*}}{2} \tag{16}$$

The coefficient β seeming in the Eq. (16) denotes a fixed parameter that can take values within the interval [0, 1]. In the current research, this coefficient is set to 0.5.

Step 3. The weighted normalized decision matrix values are identified via Eq. (17).

$$\hat{t_{ij}} = w_{ij} \times t_{ij}^{norm} \tag{17}$$

Step 4. The sum of the weighted normalized values for beneficial and non- beneficial criteria is obtained by applying Eqs. (18) and (19).

$$L_i = \sum_{j=1}^{n} \hat{t_{ij}}^{(min)} \tag{18}$$

$$A_i = \sum_{j=1}^{n} \hat{t_{ij}}^{(max)} \tag{19}$$

Step 5. In the last computational step, the performance score for each decision alternative is computed with Eq. (20).

$$R_i = {L_i}^{\lambda} + {A_i}^{(1-\lambda)} \tag{20}$$

The parameter λ seeming in Eq. (20) symbolizes the coefficient related to the characteristics of the criteria. This parameter was taken as 0.5 in obtaining the initial ranking results. Finally, compared to other decision alternatives, the bank with the highest R_i score is identified as the best-performing alternative.

4. Case Study

The present manuscript applies the combined CRISUS–MSD–AROMAN framework developed in Section 3 to the ESG performance assessment of BIST-listed deposit banks. The framework jointly determines the criterion importance weights through the CRISUS and MSD procedures and produces final performance rankings via the AROMAN procedure, yielding a fully data-driven, transparent, and reproducible evaluation of bank ESG performance. Table 1 lists the eight banks considered as alternatives in the case study, together with the codes employed in the subsequent analysis.

Table 1. Commercial Bank Alternatives

Rank	Banks	Code
1	Akbank	B1
2	ICBC Turkey Bank	B2
3	Şekerbank	B3
4	Türkiye Garanti Bankası	B4
5	Türkiye Halk Bankası	B5
6	Türkiye İş Bankası	B6
7	Türkiye Vakıflar Bankası	B7
8	Yapı ve Kredi Bankası	B8

The criteria employed to compare the ESG performance of commercial banks in the current paper consist of a total of 15 criteria across 3 dimensions. Additionally, the criteria for the decision-making problem identified in this study were identified by considering the opinions of the experts participating in this research, as well as previous studies in the literature. The environmental dimension includes 5 indicators that jointly capture banks' direct and indirect ecological footprint. The social dimension comprises 5 indicators covering the bank's human capital structure and the social orientation of its lending activities. Finally, the governance dimension comprises 5 indicators reflecting board-level oversight and sustainability governance attributes. Each indicator is classified as benefit-type (where higher values indicate better performance) or cost-type (where lower values indicate better performance), in line with standard MCDM practice. Table 2 outlines ESG dimensions, their corresponding indicators, codes, and optimization directions.

Table 2. Selected ESG Performance Indicators

Rank	Dimension	Performance Indicators	Code	Optimization
1	Environmental (E)	Total Greenhouse Gas Emissions	E1	Cost
2		Energy Consumption per Employee	E2	Cost
3		Renewable Energy Usage Ratio	E3	Benefit
4		Green Loan Ratio	E4	Benefit
5		Environmental Risk Score	E5	Cost
6	Social (S)	Female Employee Ratio	S1	Benefit
7		Female Executive Ratio	S2	Benefit
8		Training Hours per Employee	S3	Benefit
9		Employee Turnover Rate	S4	Cost
10		Socially Themed Loans to Total Loans Ratio	S5	Benefit
11	Governance (G)	Independent Board Member Ratio	G1	Benefit
12		Female Board Member Ratio	G2	Benefit
13		CEO–Chairperson Role Separation	G3	Benefit
14		Existence of an ESG / Sustainability Committee	G4	Benefit

15		Existence of an Independent Audit Committee	G5	Benefit

5. Application and Findings

In this section, the empirical results obtained by applying the hybrid methodology CRISUS–MSD–AROMAN to the problem of measuring bank performance are presented. Prior to proceeding to the application of the developed integrated methodology, an initial decision matrix is needed for the application of all the three procedures. In this regard, the decision matrix was developed by consulting the assessment of 5 experts experienced in the banking industry and in the area of ESG. These experts were chosen based on management supervision, sector practice and regulatory perspectives. The first expert is a member of the sustainability committee of a bank. The second expert is a member of the corporate governance committee of a bank. The third expert is an authorized representative at the Banking Regulation and Supervision Agency. The fourth expert is a senior executive at an Islamic bank. The fifth and last expert is an independent member of a bank's board of directors. The 5 experts initially identified 15 indicators across 3 dimensions by consensus. Subsequently, bank alternatives were evaluated in terms of the criteria determined using the nine-point linguistic evaluation framework proposed by Krstić et al. (2024): Extremely Low (EL = 1) … and Extremely High (EH = 9). This linguistic assessment method was adopted because standardized and fully comparable quantitative ESG descriptions were not consistently available across all banks in the sample. After determining the scores corresponding to each expert's independent linguistic assessments, the average of each criterion was computed based on all experts to form the initial decision matrix. Consequently, as displayed in Table 3, this matrix was created with the help of the average criteria for each alternative.

5.1. Findings Concerning the CRISUS Procedure

To obtain the initial objective weights of the ESG indicators, the CRISUS algorithm was applied to the decision matrix displayed in Table 3. In this context, the first normalized matrix values were obtained using Eqs. (2) and (3), and the second normalized matrix values were obtained using Eq. (4). Using the second normalized matrix with Eq. (5), the sum of the squares of each criterion was found, and then the standard deviation for each criterion was obtained with Eq. (6). Lastly, the first objective weight values were derived according to Eq. (7) and are given in Table 4.

Table 3. Decision Matrix

	E1	E2	E3	E4	E5	S1	S2	S3	S4	S5	G1	G2	G3	G4	G5
B1	8.60	8.00	8.60	7.80	7.80	7.80	7.80	8.40	7.60	8.20	8.80	7.80	9.00	8.60	8.40
B2	4.00	5.00	3.80	3.40	4.80	5.00	3.60	4.80	5.80	3.60	5.40	4.00	5.40	4.60	6.00
B3	5.80	5.60	5.80	7.20	6.20	6.00	5.00	6.40	5.60	7.00	6.00	5.40	6.40	5.00	6.40
B4	8.00	8.40	8.20	8.60	8.20	8.20	8.00	8.60	7.40	8.20	8.20	8.40	8.20	8.60	8.40
B5	6.20	6.40	5.40	6.40	7.00	7.00	5.40	6.40	6.00	7.40	5.60	5.60	5.60	6.60	6.60
B6	6.00	7.20	6.40	8.00	8.00	7.60	6.80	8.40	7.20	7.20	7.80	6.80	7.40	7.00	8.00
B7	6.40	6.60	6.40	6.80	7.40	6.00	5.80	6.80	5.60	6.40	6.20	5.80	6.40	6.60	7.40
B8	7.80	8.00	8.80	8.00	7.80	7.20	6.40	8.00	7.40	8.00	8.20	6.80	7.80	8.40	7.80

Table 4. Findings from CRISUS

	ρ_j	σ_j	$\rho_j \times \sigma_j$	w_j	Ranking
E1	0.125	0.011	0.001	0.075	6
E2	0.125	0.008	0.001	0.059	11
E3	0.132	0.012	0.002	0.088	2
E4	0.131	0.011	0.001	0.077	4
E5	0.125	0.007	0.001	0.052	13
S1	0.128	0.008	0.001	0.055	12
S2	0.131	0.012	0.002	0.090	1
S3	0.129	0.008	0.001	0.061	10
S4	0.125	0.007	0.001	0.049	14
S5	0.130	0.010	0.001	0.072	7
G1	0.129	0.009	0.001	0.064	8
G2	0.130	0.011	0.001	0.081	3
G3	0.129	0.008	0.001	0.061	9
G4	0.131	0.010	0.001	0.075	5
G5	0.127	0.006	0.001	0.041	15

5.2. Findings Regarding the MSD Procedure

The second objective weights of the ESG criteria were determined based on MSD procedure. Starting from the decision matrix in Table 3, this matrix was normalized through Eqs. (8)–(9), standard deviation and adjusted scores were computed using Eqs. (10)–(11), and final MSD weights were obtained according to Eq. (12). The MSD results are given in Table 5.

Table 5. Results from MSD

	σ_j	σ'	w_j	Ranking
E1	0.169	0.033	0.087	1
E2	0.142	0.024	0.063	10
E3	0.198	0.033	0.086	2
E4	0.190	0.029	0.076	4
E5	0.139	0.025	0.066	8
S1	0.133	0.020	0.052	13
S2	0.184	0.030	0.079	3
S3	0.156	0.023	0.061	11
S4	0.119	0.017	0.045	14
S5	0.184	0.027	0.071	7
G1	0.154	0.024	0.064	9
G2	0.168	0.028	0.074	6
G3	0.142	0.023	0.060	12
G4	0.182	0.028	0.074	5
G5	0.111	0.016	0.042	15

5.3. Results Relating to Final Weighting Procedure

The first and second weight coefficients computed for the ESG indicators based on the CRISUS and MSD approaches are combined via the linear aggregation operator

defined in Eq. (13). Accordingly, the final weight coefficients for each indicator are obtained. The weights computed for each criterion are given in Figure 2. The final weighting findings indicate that ESG performance in the banking sector is predominantly shaped by environmental criteria. In particular, E3 (renewable energy usage ratio) emerges as the most influential criterion (ranked 1st), followed by S2 (female executive ratio, 2nd), E1 (total greenhouse gas emissions, 3rd), G2 (female board member ratio, 4th) and E4 (green loan ratio, 5th). The leading positions of E3, E1 and E4 display that sustainable finance practices and environmental risks play a determinant role in overall ESG performance of banks, while the high weight of S2 point out that board-level gender diversity also constitutes a meaningful differentiator across banks.

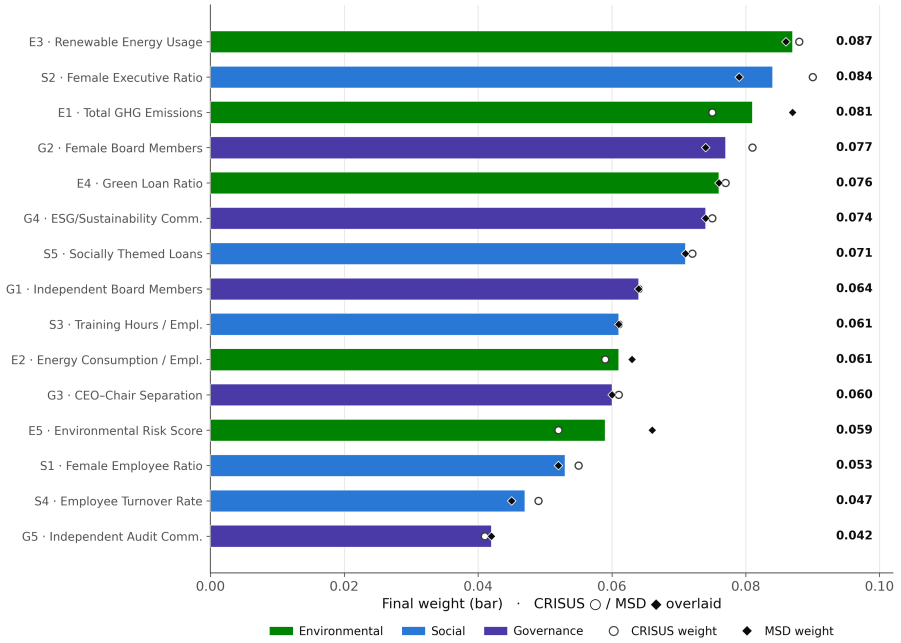


Figure 2. Findings from Final Weighting

5.4. Results Regarding the AROMAN Procedure

The initial decision matrix given in Table 3 is prepared for the application of the AROMAN algorithm. Subsequently, this matrix is normalized using the two-step normalization structure in Eqs. (14)–(16), with the parameter β set to 0.5. Next, the weighted normalized values are computed via Eq. (17), and the beneficial and non-beneficial criterion components are aggregated using Eqs. (18)–(19). Finally, the overall AROMAN performance scores are obtained according to Eq. (20), with λ set to 0.5. The resulting AROMAN rankings are displayed in Figure 3.

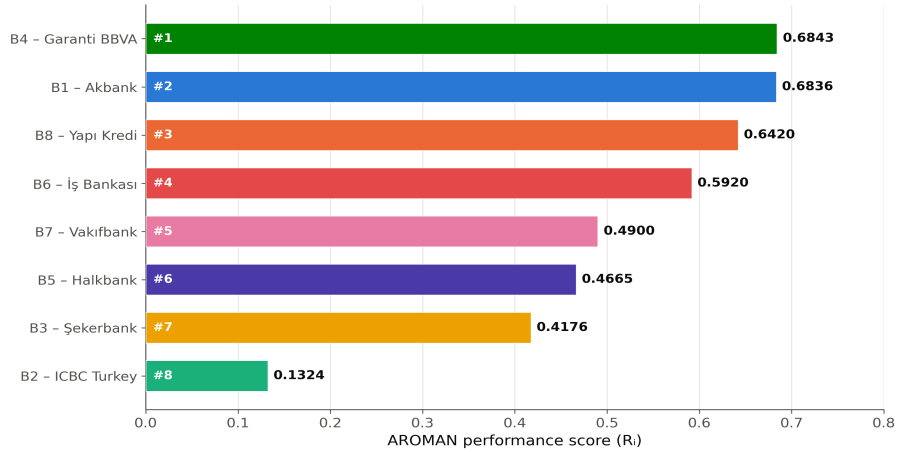


Figure 3. Results from AROMAN Approach

The AROMAN results in Figure 3 designate that Garanti BBVA (B4) achieved the highest overall ESG performance score and therefore ranked first among the sampled banks. On the other hand, ICBC Turkey (B2) received the lowest performance score, placing it at the bottom of the ranking. This finding indicates a clear performance gap between the best and worst performing banks in terms of the selected ESG criteria.

6. Sensitivity Investigation

To show the dependability and validity of the introduced tool for assessing ESG performance in the banking industry, this section conducts a series of sensitivity analyses. These analyses are essential for testing the methodological robustness of the framework, investigating the influence of potential variations in the criterion weight values on the rankings, and assessing the stability of the empirical findings.

6.1. Influence of Changes in Criterion Weights on Bank Rankings

This article applies the sensitivity analysis used by Tekgün (2025) to test the robustness of the proposed hybrid model against changes in the calculated weight values in the ESG performance measurement problem. Specifically, the final weight of the criterion identified as the most influential for ESG performance (E3) is reduced by 5% in each scenario, yielding a total of 100 scenarios. The corresponding weight reduction is proportionally and evenly redistributed across the remaining criteria to generate a new weight vector for each scenario. The AROMAN method is then re-applied to each weight vector, and any variations in the rankings of bank alternatives are systematically tracked. The outcomes show that the imposed variations in the criterion weight values do not produce material changes in the rankings of banks, thereby supporting the robustness and stability of the introduced hybrid methodology. The outcomes of this sensitivity analysis are illustrated in Figure 4.

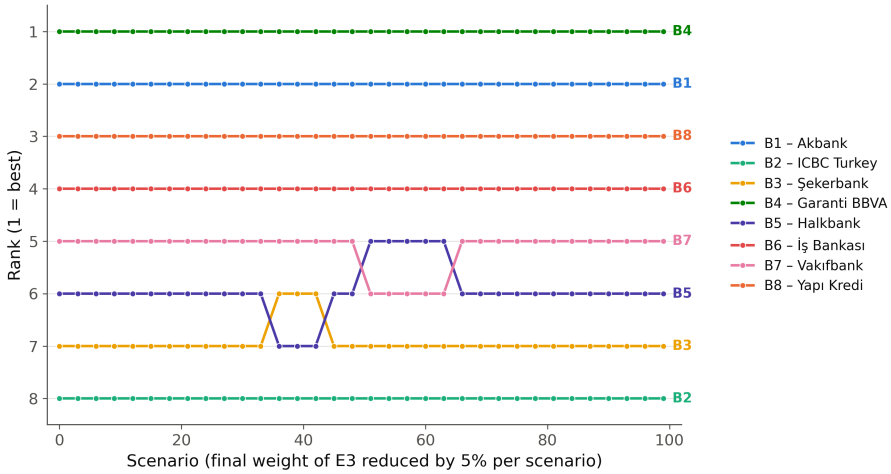


Figure 4. Re-ranking Banks with New Weightings

6.2. Sensitivity Analysis of the ψ Aggregation Parameter

This subsection investigates the influence of variations in the ψ parameter — utilized in the determination of the final weights — on the ESG performance rankings is tested. Although ψ is typically set to 0.5 in the current literature (Işık et al., 2025c), it can in principle take any value within the [0, 1] interval. Accordingly, ten scenarios are constructed by varying ψ between 0 and 1, and the AROMAN procedure is applied to each scenario. The results shown in Figure 5 indicate that systematic changes in ψ do not produce any meaningful variation in the ESG performance of the banks, confirming that the introduced hybrid approach is highly stable and reliable in terms of parameter sensitivity.

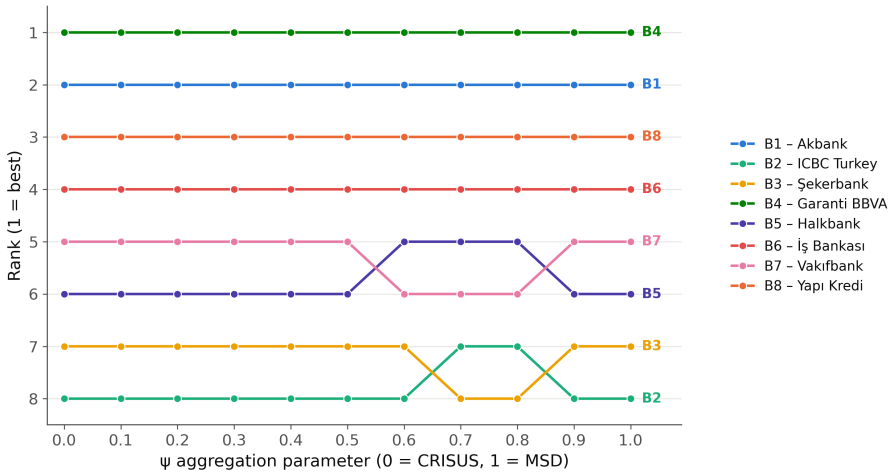


Figure 5. Re-ranking of Banks in terms of the ψ Parameter

6.3. Analysis of the Rank Reversal Phenomenon

To further examine the ranking robustness of the recommended approach, a rank-reversal analysis — widely used in the MCDM literature — is conducted. Following the approach utilized by Tekgün (2025), the bank with the lowest ESG performance is removed from the sample in each scenario and the evaluation procedure is repeated. The ranking results from the eight resulting scenarios, in each of which the top-performing bank is retained, are displayed in Figure 6. The results indicate that eliminating the lowest-performing bank does not change the final rankings of the remaining alternatives.

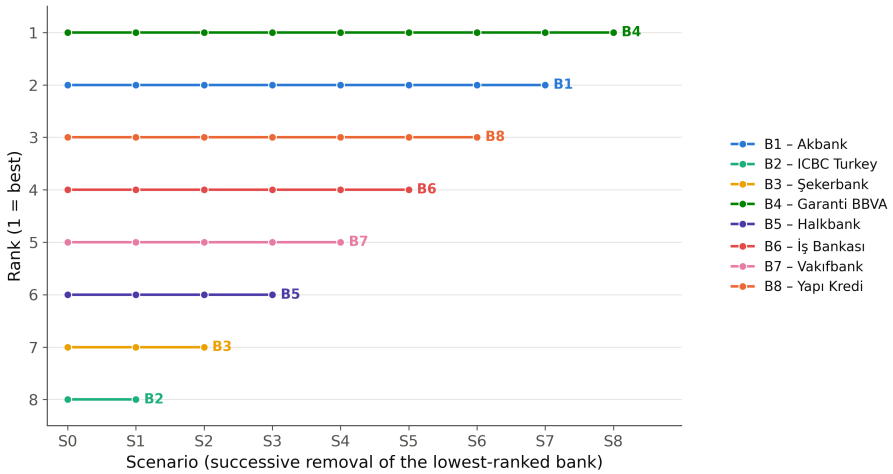


Figure 6. Ranking of Banks across Different Scenarios

7. Results and Discussion

Assessing ESG performance in the banking industry has become a critical dimension of contemporary financial analysis, reflecting both regulatory expectations and market-driven imperatives. Banks, as key institutions in capital allocation and risk management, are increasingly being evaluated not only on their financial results but also on their capacity to integrate ESG principles into their strategic decision-making processes. Accordingly, the existing manuscript introduces a comprehensive MCDM methodology to gauge the multidimensional ESG performance of banks. CRISUS and MSD are utilized to calculate the weight coefficients of criteria, while AROMAN is used to rank bank alternatives. The applicability of the developed MCDM tool is demonstrated with the aid of a real-world case study of deposit banks listed on BIST.

The final weighting findings from the CRISUS and MSD methods clearly show that ESG performance in the banking industry is predominantly shaped by environmental criteria. Specifically, the high weightings assigned to total greenhouse gas emissions, renewable energy use rate, and green loan rate underscore the decisive role of environmental risk management and sustainable finance practices in banks' ESG performance. On the other hand, the relatively low weightings attributed to the presence of an independent audit committee, employee turnover rate, and the proportion of female employees show that these metrics have limited discriminatory power due to their widespread and relatively homogeneous application across banks.

These findings suggest that ESG performance in the banking industry is largely centered around environmental transformation dynamics.

The ranking results from the AROMAN procedure reveal a significant differentiation in ESG performance among listed commercial banks. Garanti BBVA, Akbank, and Yapı Kredi occupy the top three positions, demonstrating a more balanced performance profile across environmental sustainability, social practices, and governance structures. In contrast, ICBC Turkey, Şekerbank, and Halkbank are ranked lower, indicating relatively weaker performance in the ESG dimensions.

While this manuscript offers valuable insights into assessing ESG performance in the banking industry, it is subject to certain limitations. First, the analysis is limited to a single, most recent reporting period and deposit banks listed on the BIST. Second, ESG performance is assessed within the confines of the selected set of criteria; the inclusion of alternative indicators or an extended temporal dimension may yield different results. Future research could expand the proposed framework by including other country groups, longitudinal analyses, or grey and fuzzy extensions. Besides, investigating the association between ESG performance and financial performance or market capitalization through integrated modeling approaches could further contribute to the literature. Overall, this research provides a methodologically robust, practically applicable, and decision-support-oriented methodology for the holistic assessment of ESG performance in the banking industry. The findings have significant implications for the academic literature as well as for bank executives, investors, and regulatory authorities. More specifically, the inclusion of alternative ESG indicators—such as ESG controversy, Scope 3 emissions, board ESG-linked compensation, and customer-level financial-inclusion metrics—or the extension of the sample to several consecutive reporting years could alter the relative criterion weight values and, potentially, the bank rankings. Finally, because the decision matrix is obtained from linguistic judgments of experts, the findings carry an inherent degree of evaluator subjectivity; future papers could diminish this by enlarging the expert panel or by adopting fuzzy or grey information to model assessment uncertainty.

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