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Business Competitiveness in Sustainable Finance: A Comprehensive ESG Performance Analysis of Top OECD Banks

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Abstract: This study examines business competitiveness in sustainable finance within the OECD banking sector, focusing on how Environmental, Social, and Governance (ESG) performance contributes to strategic positioning in a knowledge-based economy. As financial institutions operate in increasingly complex global environments, integrating ESG factors has become a critical managerial tool for enhancing competitiveness, fostering innovation, and strengthening institutional resilience. The study is framed within the perspective of management dynamics, emphasizing how banks adapt their strategies and capabilities to address sustainability pressures across diverse national contexts. The current literature emphasizes the growing importance of ESG performance in influencing financial outcomes, stakeholder trust, and long-term stability. However, most studies focus on single countries, rely on subjective weighting methods, or overlook cross-country comparisons. This creates a gap in understanding how ESG-driven competitiveness develops across different economies and how organizational strategies and knowledge-based resources impact sustainable banking performance. To address this gap, the study employs a multi-criteria decision-making framework integrating entropy-based weighting with the Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS). Using Refinitiv ESG data from 2018 to 2023, the analysis evaluates 138 banks across 29 OECD countries based on five ESG dimensions: overall ESG score, shareholder score, CSR strategy, emissions, and resource use. This approach offers a comparative, knowledge-driven benchmarking framework for assessing sustainable competitiveness. The results reveal significant variations in ESG-based competitiveness across countries. Governance and strategic ESG indicators emerge as the most influential drivers of competitive advantage, while environmental dimensions remain unevenly implemented. These findings suggest that ESG serves as a strategic knowledge resource that shapes managerial decision-making and institutional performance. This study contributes by presenting an interdisciplinary, knowledge-economy-oriented framework for evaluating sustainable banking competitiveness. It provides cross-country insights supporting strategic management, sustainability transformation, and knowledge-driven policy design, thereby advancing research on management dynamics within the knowledge economy.

Keywords: ESG performance; sustainable finance; knowledge economy; OECD banking sector; sustainability management; entropy–TOPSIS.

Introduction

Business competitiveness in sustainable finance has become a central concern for the OECD banking sector, where institutions must balance financial performance with Environmental, Social, and Governance (ESG) criteria and long-term sustainability management. ESG factors have been shown to be crucial drivers of banking performance and risk-adjusted outcomes (Sun et al., 2024). As banks operate in increasingly complex global environments, their ability to integrate ESG principles into core strategies has emerged as a decisive factor in maintaining competitiveness and institutional credibility (Cicchiello et al., 2023). Within the contemporary knowledge economy, intangible

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resources such as governance quality, stakeholder trust, and sustainability capabilities play a vital role in shaping organizational performance and strategic positioning. ESG scores provide information beyond traditional financial metrics and significantly influence corporate financial outcomes (Chen & Xie, 2022; Fatemi et al., 2018).

Yuen et al. (2022) argue that ESG performance has become a key indicator of sustainability and ethical responsibility in the banking industry, reflecting the growing expectations of regulators, investors, and society. In this context, ESG integration is no longer viewed merely as a regulatory or reputational obligation but as a strategic tool for enhancing sustainable finance outcomes and long-term competitiveness. As financial markets evolve, banks are increasingly required to align their operations with sustainability principles while maintaining efficiency, transparency, and effective risk management.

Previous studies (Alamsyah & Muljo, 2023; Cai et al., 2023; Mititean & Sărmaș, 2023; Yuen et al., 2022; Zamfiroiu & Pînzaru, 2021) have demonstrated that ESG integration enhances institutional transparency, financial performance, stakeholder trust, and long-term stability, thereby bolstering competitiveness within the banking sector. These studies underscore the increasing significance of ESG performance as a strategic element in sustainable finance and sustainability management. However, much of this research remains confined to specific industries, single-country analyses, or particular regional contexts and often depends on subjective weighting methods. This fragmented approach limits the development of integrated, cross-country frameworks capable of comparing ESG performance across the OECD banking sector within the knowledge economy.

Further research (Aleksandrovna et al., 2024; Ma et al., 2024; Nian & Said, 2024; Xu et al., 2024) demonstrates that ESG integration enhances disclosure quality, risk management, and institutional value, reinforcing its role as a strategic driver of competitiveness in sustainable finance. These studies also reveal significant regional disparities in ESG-driven competitiveness, attributable to differences in institutional environments, governance structures, and regulatory systems. Such findings underscore the need for objective and comparable evaluation models capable of assessing ESG-based competitiveness across countries, particularly within the OECD banking sector, where consistent benchmarking is essential for advancing sustainability management in the knowledge economy.

Moreover, many earlier studies rely on subjective weighting techniques or traditional finance-based evaluation models that fail to capture the multidimensional nature of ESG-related competitiveness. Previous research (Alves & Meneses, 2024; Benuzzi et al., 2025; Martiny et al., 2024) demonstrates that differences in ESG assessment methodologies, weighting structures, and conventional risk measures often result in inconsistent or incomplete evaluations of sustainability performance. This indicates that traditional financial indicators alone cannot fully reflect the complexity and multidimensionality of ESG outcomes.

In response to these gaps, this study proposes a comprehensive analysis of business competitiveness in sustainable finance by examining the ESG performance of leading banks within the OECD banking sector. The study employs an entropy–TOPSIS multi-criteria decision-making framework to evaluate five ESG dimensions: overall ESG score, shareholder score, CSR strategy, emissions, and resource use. This approach offers an objective, knowledge-driven benchmarking model for assessing sustainability management and competitive positioning across countries. The purpose of this study is to evaluate ESG-based competitiveness among leading OECD banks, identify the most influential ESG dimensions, and offer cross-country insights into sustainable finance within the context of a knowledge economy. By integrating ESG performance with the

entropy–TOPSIS method, this study enhances the understanding of competitiveness dynamics and sustainability-oriented strategies in the OECD banking sector.

This study's originality is demonstrated in four key ways. First, it provides a cross-country benchmark of OECD banks using entropy–TOPSIS across five disaggregated ESG dimensions. Second, it integrates ESG competitiveness within a knowledge-economy framework by linking ESG performance to knowledge-based capabilities, transparency, learning, and stakeholder trust. Third, it advances prior research by employing objective entropy-based weighting alongside sensitivity and bootstrap robustness analyses. Finally, it develops a conceptual framework explaining how ESG dimensions translate into competitiveness through knowledge-based capabilities in the banking sector.

Literature review

ESG Performance and competitive dynamics in the OECD banking sector

In today's knowledge economy, ESG performance has become a key determinant of competitiveness in the banking industry, as regulatory pressures and stakeholder expectations increasingly emphasize sustainability, transparency, and ethical accountability. A previous study by Azmi et al. (2021) demonstrated that integrating ESG factors enhances financial performance, disclosure quality, risk management, and firm value, positioning ESG as a strategic resource rather than merely a compliance requirement. These findings suggest that sustainable finance practices are closely linked to long-term competitiveness and institutional resilience.

However, ESG-driven competitiveness remains uneven across the OECD banking sector. Research by Cornett et al. (2016) indicates that institutional context, governance structures, and firm-specific characteristics significantly influence ESG outcomes, resulting in regional disparities in banking performance. Regulatory fragmentation and inconsistent alignment with global sustainability standards further hinder ESG adoption in certain jurisdictions (Baker McKenzie, 2021). Additional studies emphasize the importance of transparency and disclosure quality in improving environmental and social outcomes (Mazzioni et al., 2024), while robust ESG implementation enhances credibility, reduces financial and credit risks, and contributes to financial system stability (Abdul Razak et al., 2023; KPMG, 2023). These findings demonstrate that sustainability management plays a critical role in shaping competitiveness within modern banking systems.

Theoretical perspectives on sustainable finance and competitiveness

The strategic importance of ESG performance in banking is rooted in Stakeholder Theory and Sustainable Development Theory. Stakeholder Theory posits that organizations gain a competitive advantage by addressing the interests of multiple stakeholders, including investors, regulators, customers, and society (Freeman, 1984). Sustainable Development Theory emphasizes long-term viability through responsible resource use, resilience, and alignment with environmental and social priorities (World Commission) on Environment and Development, 1987. Together, these perspectives support the view that integrating ESG factors enhances both organizational legitimacy and long-term performance.

Empirical evidence supports these theoretical arguments. Previous studies (Maside-Sanfiz et al., 2024; Shan et al., 2025) demonstrate that higher ESG engagement enhances institutional stability, reputational capital, and strategic outcomes in banking. Similarly, studies (Horobet et al., 2025; Waktola et al., 2024) show that banks that effectively integrate ESG principles are better positioned to attract capital, mitigate risks, and build stakeholder trust. These findings underscore ESG performance as a critical component of sustainable finance and competitive positioning within the knowledge economy.

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Nevertheless, ESG-focused research within the OECD banking sector remains limited in scope, highlighting the need for cross-country benchmarking and objective competitiveness assessments.

ESG, knowledge economy, and competitive advantage

Within the knowledge economy, ESG performance can be viewed as an intangible strategic resource rather than a compliance-based metric. From a Resource-Based View (RBV), ESG-related routines, governance quality, disclosure capabilities, and stakeholder alignment constitute valuable, rare, and inimitable resources that support sustainable competitive advantage. From a Knowledge-Based View (KBV), ESG practices enhance organizational learning, information integration, risk anticipation, and strategic adaptation (Gillan et al., 2021).

Grounded in Stakeholder Theory, Sustainable Development Theory, and the RBV and KBV perspectives, this study conceptualizes ESG as a strategic, knowledge-based capability. Accordingly, a conceptual framework (Figure 1) is developed to link ESG dimensions with business competitiveness in the OECD banking sector.

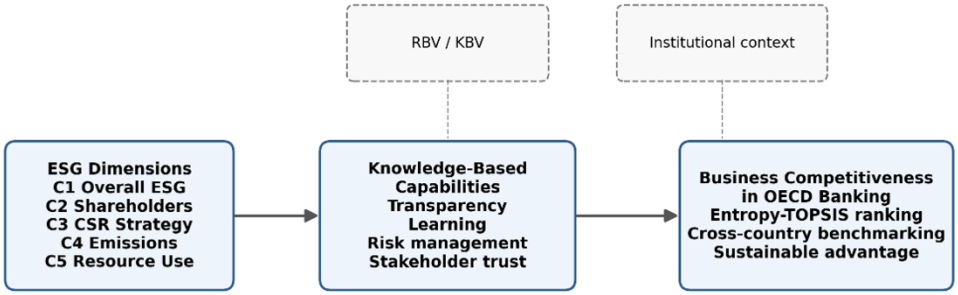

Figure 1. Conceptual framework
Source: own processing

The framework demonstrates how ESG capabilities improve decision-making, reputational capital, funding conditions, regulatory responsiveness, and stakeholder trust by transforming sustainability-related information into strategic actions.

Methodological gaps and the need for objective ESG competitiveness assessment

Despite the growing body of research on ESG and sustainable finance, significant methodological gaps persist. Previous studies (Lebbar & El-Aroui, 2026; Lee et al., 2025) indicate that many ESG evaluations are context-specific, lack cross-country comparability, and rely on subjective weighting schemes that compromise consistency. Furthermore, limited attention has been given to ESG-driven competitiveness as a multidimensional construct encompassing governance quality, environmental risk management, and strategic sustainability orientation across international markets (Korankye et al., 2025; Mirza et al., 2025).

To address these limitations, recent studies advocate using objective, data-driven evaluation models that capture the multidimensional nature of ESG performance (Bouattour et al., 2024; Xi & Wang, 2024). The integration of entropy weighting with the TOPSIS method provides a transparent and replicable framework for cross-country benchmarking by assigning objective weights to ESG dimensions and ranking institutions based on their proximity to an ideal sustainability profile (Zournatzidou et al., 2025). Compared to traditional financial valuation models, such as price-to-earnings (P/E) ratios or discounted cash flow models, this approach more effectively captures the complex drivers of competitiveness in sustainable finance.

Building on these insights, the present study examines ESG-driven competitiveness within the OECD banking sector using an entropy–TOPSIS framework. By evaluating five ESG sub-dimensions, the study offers an objective benchmarking model for sustainability management in the knowledge economy. This approach overcomes the limitations of prior research by providing a comprehensive, cross-country analysis of ESG-based competitiveness and identifying strategic sustainability patterns among leading OECD banks.

Research methodology

The study employs a three-phase framework (Figure 2) to evaluate ESG-based competitiveness. First, a decision matrix is constructed using five ESG criteria: ESG (C1), Shareholders (C2), CSR Strategy (C3), Emissions (C4), and Resource Use (C5). Second, the entropy method is applied to determine objective weights. Third, the TOPSIS method ranks banks according to their proximity to the ideal ESG performance.

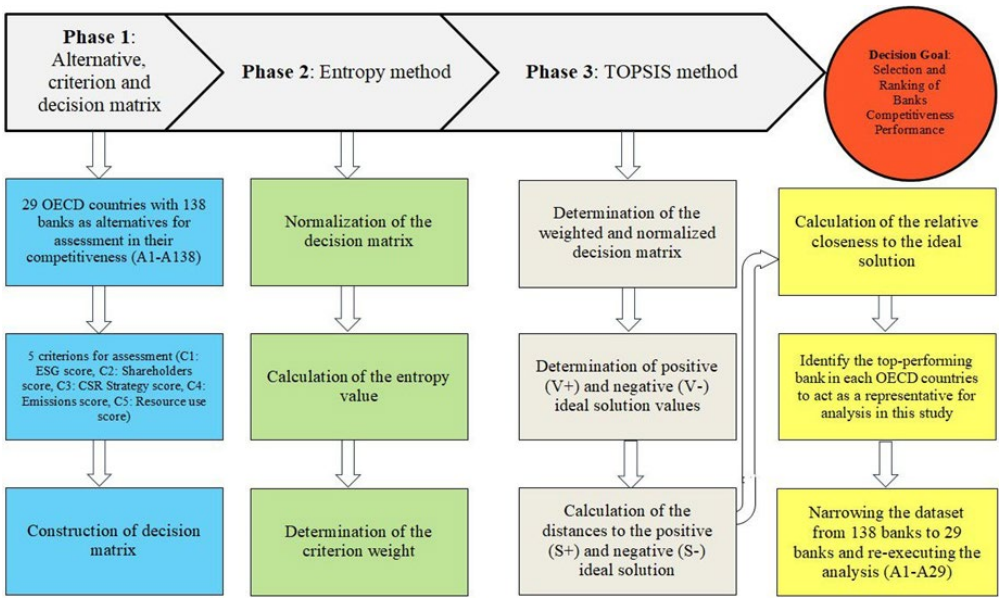

Figure 2. Research workflow diagram
Source: own processing

This study employs the entropy–TOPSIS method to establish a hierarchical ranking of OECD banks. To enhance methodological transparency, the sample selection procedure was refined. The initial Refinitiv dataset included 1,145 banks from 38 OECD member countries over the period 2018–2023. Following rigorous data cleaning to ensure completeness and reliability across all five ESG dimensions, the sample was reduced to 138 banks from 29 countries with complete data. To ensure balanced cross-country comparability and avoid over-representation, only the top-performing bank from each country was retained, resulting in a final sample of 29 banks. The entropy–TOPSIS analysis was then re-executed on this refined dataset. Figure A1 in the Appendix illustrates the selected banks and highlights the top five performers. This refinement ensures a consistent and comparable dataset across countries.

The steps involved in this method are as follows:

Step 1: Create a data evaluation matrix, where:

$$C_1\, C_2\, \ldots C_n$$

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$$D = \left[x_{ij}\right]_{mxn} = \begin{matrix} A_1 \\ A_2 \\ \vdots \\ A_m \end{matrix} \begin{bmatrix} x_{11}x_{12}\cdots x_{1n} \\ x_{21}x_{22}\cdots x_{2n} \\ \cdots \quad \cdots \quad \ldots \quad \cdots \\ x_{m1}x_{m2}\ldots x_{mn} \end{bmatrix} mxn$$
$$i = 1,2,\ldots,m, j = 1,2,\ldots,n \qquad (1)$$

This matrix (Formula 1) serves as the foundation for the subsequent steps in the methodology, where the data will be normalized, weighted, and analyzed to determine the ESG performance rankings of the banks (Ke et al., 2024). By creating a comprehensive data evaluation matrix, the study ensures that the analysis is based on accurate and well-organized data, leading to reliable and meaningful results.

Step 2: Normalizing the following matrix, where:

$$r_{ij} = \frac{x_{ij}}{\sqrt{\sum_{i=1}^{m} x_{ij}^2}} \qquad (2)$$

The normalization process (Formula 2) is crucial for ensuring that the ESG scores are comparable across different scales. Prior authors have applied this formula. By converting the raw scores into normalized values, the study can accurately assess the relative performance of each bank (Weng & Yang, 2022). This step is essential for the subsequent analysis using the entropy method and TOPSIS.

Step 3: Entropy-based calculation of the objective weight, where:

$$e_j = -\left(\frac{1}{ln\,(m)}\right)\sum_{i=1}^{m}(r_{ij}\,ln\,(r_{ij})) \qquad (3)$$

The entropy-based calculation (Formula 3) is crucial for determining the objective weights of each attribute in the ESG performance evaluation. By calculating the entropy values, the study can assess the level of uncertainty and variability in the ESG scores, which in turn reflects the relative importance of each attribute. This step is essential for the subsequent integrated assessment using the TOPSIS method (Luo et al., 2025).

Step 4: Integrated assessment, whereby:

$$V_{ij} = r_{ij}\ x\ w_j \qquad (4)$$

Step 5: Benefit or cost of each criterion should be the minimum or maximum value, respectively, where:

$$V^+ = \{v_1^+, v_2^+, \ldots, v_n^+\}$$
$$V^- = \{v_1^+, v_2^+, \ldots, v_n^+\} \qquad (5)$$

This step (Formula 5) involves identifying whether each criterion (attribute) should be maximized (benefit) or minimized (cost). This step is crucial for accurately evaluating the performance of each bank based on the given criteria. This formulation follows prior applications (Guo et al., 2024). The positive ideal solution represents the best possible performance for each attribute. It is the maximum value for benefit criteria and the minimum value for cost criteria. The negative ideal solution represents the worst possible performance for each attribute. It is the minimum value for benefit criteria and the maximum value for cost criteria.

Step 6: Calculate the closeness of the sample being classified to both the ideal positive and negative reference points, where:

$$S_I^+ = \sqrt{\sum_{J=1}^{n}(v_{ij} - v_j^+)^2}$$

$$S_I^- = \sqrt{\sum_{J=1}^{n} (v_{ij} - v_j^-)^2} \quad (6)$$

The identification of positive and negative ideal solutions (Formula 6) is crucial for evaluating the relative performance of each bank. By comparing the actual performance of each bank to these ideal solutions, the study can assess how close each bank is to the best possible performance and how far it is from the worst possible performance. This step provides a clear benchmark for evaluating the ESG performance of banks and identifying areas for improvement.

Step 7: Computation of the relative ability indicator value, where:

$$C_i = \frac{S_i^-}{S_i^+ + S_I^-} \quad (7)$$

The relative ability indicator value (Formula 7), denoted Ci, is calculated for each bank. This value represents the relative closeness of each bank to the ideal solution, providing a measure of how well each bank performs in terms of ESG criteria compared to the best and worst performers (Xueshan et al., 2025).

Step 8: Ranking

The ESG-based ranking of banks provides critical insights into institutional strengths, weaknesses, and relative competitiveness. The integration of entropy weighting with the TOPSIS method ensures that ESG indicators are assigned objective weights reflecting their informational importance, thereby producing a transparent and reliable ranking. ESG scores are first normalized, after which entropy weights are calculated to capture the relative contribution of each ESG dimension. TOPSIS then ranks banks according to their proximity to an ideal ESG performance benchmark, enabling the identification of leading institutions and areas requiring improvement. The results facilitate the diffusion of best practices among banks and offer actionable guidance for policymakers and regulators seeking to strengthen ESG standards and promote sustainable banking within OECD countries.

To enhance the empirical credibility of the ranking results, an additional robustness and sensitivity analysis framework was incorporated (Więckowski & Sałabun, 2023). First, a Monte Carlo weight-perturbation procedure was implemented, in which entropy weights were repeatedly varied within a controlled interval to assess whether the bank rankings remained stable under plausible weighting uncertainty.

Second, a bootstrap-based rank stability procedure was conducted by resampling yearly observations and recomputing the entropy–TOPSIS rankings across multiple iterations. Finally, a t-test was performed to examine statistical differences in the results. These procedures enable the study to report ranking persistence, average rank, rank dispersion, and top-position frequency, thereby strengthening the methodological robustness of the research.

Results and discussion

Table 1 presents the preprocessed decision matrix for 29 top-performing banks, one from each OECD country, ensuring data consistency across the analysis. Covering five ESG criteria (C1–C5) for 2018–2023, the matrix reveals substantial cross-country variation in sustainability performance and competitive positioning. These findings align with prior research on uneven ESG outcomes (Gutiérrez-Ponce & Wibowo, 2022, 2024), and highlight the importance of ESG criteria in institutional sustainability. Overall, the results provide valuable benchmarking insights into ESG-driven competitiveness in the OECD banking sector.

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Table 1. Bank Evaluation Matrix

Alternatives	2018					2019					2020				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
A1	7707	9481	9864	6200	8440	7634	9681	9803	8675	8757	7393	9376	9853	8532	8993
A2	2291	9669	6136	386	2	3267	9698	5290	1789	3057	4782	9716	4702	3084	4516
A3	4230	4674	8872	4815	8089	4474	5840	9789	5222	8506	3901	4150	9588	4742	7623
A4	1798	2116	2165	751	692	1997	1205	2018	930	774	1568	1142	1409	1552	2289
A5	1703	5031	3999	2252	480	1828	3657	9724	3067	677	3232	3798	9281	7344	3255
A6	1716	686	1056	1199	1519	2527	2999	2744	7427	4642	2757	7071	4649	9567	4850
A7	3419	7656	1406	4204	4245	2737	3906	3906	4951	5277	3988	3906	5625	9158	6427
A8	873	319	4064	2006	2104	1047	1947	4211	3137	1527	2489	2983	6268	3005	1877
A9	5610	9752	5439	5746	8593	4621	8214	5081	5946	8547	5028	8718	9864	5087	9573
A10	8966	6944	9862	9551	7317	9080	6551	9801	9561	7460	9027	6426	8686	8761	7855
A11	5025	9489	5576	4927	5190	5562	9253	5758	5469	5178	6176	9254	9700	6785	6887
A12	5342	5765	7857	5828	7893	5407	8879	9571	6997	7935	5898	8919	9571	9328	8259
A13	5240	2500	1406	3832	316	3317	2500	1406	5688	1563	5449	2500	1406	6498	3406
A14	3593	5006	3452	680	1585	3488	1985	1824	2010	1774	3527	6314	1567	3025	4591
A15	5917	8789	7901	6982	7176	6330	6944	6944	8248	7894	6062	6400	8976	8274	8057
A16	3226	9506	6590	3571	2930	5755	7406	6530	6479	5642	5878	7820	6742	6191	5924
A17	6096	7071	7068	7809	2990	5631	6208	6833	7684	2466	5687	8763	9328	7649	2860
A18	6031	9928	2765	8683	2180	6459	9813	3070	8714	2422	6626	8997	6902	6584	1845
A19	3433	8314	9763	2677	1292	3275	7100	4351	5594	1475	3208	6757	3996	5262	1610
A20	4692	2786	9025	4273	9324	4433	2113	8830	4375	9534	4855	2616	8540	4621	8294
A21	5258	2870	5740	376	2233	4527	1544	4504	467	2400	4424	2500	5154	516	2820
A22	5015	544	6747	9189	4762	6165	278	6747	9235	6161	5534	100	6173	8370	6247
A23	7534	9099	9724	5115	9483	7073	8442	9481	5099	9314	6233	8656	9245	6054	8957
A24	1927	3411	1121	1443	3	1552	2445	1474	541	9	1694	2560	1745	524	218
A25	4754	4090	8692	8205	8035	4195	1947	8705	6826	7777	4243	2475	8348	5216	8276
A26	5310	1125	9299	7389	9862	5537	539	9318	7247	9843	5413	699	9328	7436	9720
A27	7393	8039	7027	4134	7458	7410	7923	7969	4264	5609	7832	8588	5657	4271	5753
A28	4125	6257	689	560	504	4418	5300	516	707	463	4400	6249	2143	1164	296
A29	6619	9481	8649	9086	5553	6956	8623	8403	9155	6889	6384	7656	6740	8859	9645

Source: own processing

Table 1. Bank Evaluation Matrix (continued)

Alternatives	2021					2022					2023				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
A1	7367	9266	9902	9415	9014	7049	9224	9880	9497	9382	7410	8896	9855	9392	9374
A2	5293	9160	3774	3303	3715	5237	9183	3906	4432	3475	5586	8150	3402	3851	3032
A3	3791	4018	9633	4908	7850	3544	3190	9626	3940	7942	3843	5492	9639	6647	7813
A4	2295	1370	5797	3415	2568	2257	2125	6994	4543	3063	2408	1009	6887	3910	3693
A5	4012	2191	9783	7751	5335	3507	1233	9783	7714	5660	4165	952	9783	7960	6067
A6	4977	8683	5625	9849	8477	6098	7762	4768	9940	8671	6414	4768	4768	9849	7562
A7	3197	3906	3906	9712	6966	4281	4900	4900	9635	7290	4154	3906	3906	9641	7951
A8	1768	909	6089	3208	3149	2051	4676	5240	3676	3092	1828	3058	8664	3215	4064
A9	5740	7604	9864	5162	9596	5791	7120	9864	6285	9460	5835	7086	9864	5891	9500
A10	8913	5914	8688	8938	7877	8658	5399	8821	8949	8823	8558	6815	8757	7836	8138
A11	5814	8387	9797	7533	7245	5834	6065	9720	6686	7086	5537	5216	9728	6273	6879
A12	6508	9633	9571	7200	9042	6384	7732	7825	6706	9126	7051	9645	9245	7590	9076
A13	5144	3402	3402	8021	4268	4721	459	4133	7424	4341	4942	459	4133	6992	4315
A14	4194	6602	1089	3383	5117	3325	1441	1156	3109	5170	3429	1132	1089	2623	4932
A15	5706	5825	9111	8523	8256	6165	8964	8403	8460	8230	6706	8985	8694	7672	6311
A16	5015	5625	5831	6183	6230	6453	6711	5655	5787	6153	6437	8845	5061	5573	6901
A17	6309	8361	9817	7799	3321	5147	4478	9704	5877	4591	5018	2934	9688	5784	4332
A18	6252	9366	6944	5323	936	6065	8813	6677	5104	1865	6390	9120	6446	4282	1410
A19	3905	2796	3686	5589	890	5222	9530	3313	6745	2500	4484	8940	2874	4593	3147
A20	4434	1687	8540	4986	7716	4433	3216	8540	4151	7635	3641	3296	9874	5383	3490
A21	7069	3798	8817	3192	5445	6999	7877	8521	3297	6688	6543	5721	4504	4087	6394
A22	5855	100	5625	8447	6616	6228	100	5625	8658	8181	6311	100	5878	7611	8021
A23	7300	7739	9245	6292	9685	8316	9392	9630	7100	9694	8446	8866	9610	9347	9730
A24	3315	5940	5685	928	700	2890	6073	8776	3861	638	3576	4716	8705	4778	3036
A25	4754	6626	8314	4987	8268	5107	5663	9368	6103	8429	5104	4886	9399	5358	8154
A26	5341	572	9756	7606	9864	5750	476	9555	7672	9203	6260	1877	9421	7150	4138
A27	7604	8486	9132	4039	6183	8236	7877	8959	4352	5421	8246	7273	8750	4146	4951
A28	4099	4721	2177	2726	244	3637	4707	3944	4986	268	3349	5150	3946	4375	738
A29	5709	3476	6162	8219	9567	6902	8245	4889	8549	9616	6082	7007	3783	8212	9628

Source: own processing

Table 2 reports the normalized ESG performance scores (C1–C5) for 2018–2023 (Formula 2), highlighting significant regional disparities within the OECD banking sector.

Table 2. Normalization

Alternatives	2018					2019					2020				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
A1	0.24	0.24	0.24	0.22	0.25	0.24	0.25	0.24	0.24	0.25	0.23	0.24	0.23	0.23	0.24
A2	0.13	0.24	0.19	0.05	0.00	0.15	0.25	0.17	0.11	0.15	0.18	0.24	0.16	0.14	0.17
A3	0.18	0.17	0.23	0.19	0.25	0.18	0.20	0.24	0.18	0.24	0.16	0.16	0.22	0.17	0.22
A4	0.12	0.11	0.11	0.08	0.07	0.12	0.09	0.11	0.08	0.07	0.10	0.08	0.09	0.10	0.12
A5	0.11	0.17	0.15	0.13	0.06	0.12	0.15	0.24	0.14	0.07	0.15	0.15	0.22	0.21	0.14
A6	0.11	0.06	0.08	0.10	0.11	0.14	0.14	0.13	0.22	0.18	0.14	0.21	0.16	0.24	0.17
A7	0.16	0.21	0.09	0.18	0.18	0.14	0.16	0.15	0.18	0.19	0.17	0.15	0.17	0.23	0.20
A8	0.08	0.04	0.15	0.12	0.13	0.09	0.11	0.16	0.14	0.10	0.13	0.13	0.18	0.13	0.11
A9	0.20	0.24	0.18	0.21	0.26	0.18	0.23	0.17	0.20	0.24	0.19	0.23	0.23	0.17	0.24
A10	0.26	0.20	0.24	0.27	0.24	0.26	0.21	0.24	0.25	0.23	0.25	0.20	0.21	0.23	0.22
A11	0.19	0.24	0.18	0.19	0.20	0.20	0.25	0.18	0.19	0.19	0.21	0.24	0.23	0.20	0.21
A12	0.20	0.18	0.21	0.21	0.25	0.20	0.24	0.23	0.21	0.24	0.20	0.23	0.22	0.24	0.23
A13	0.20	0.12	0.09	0.17	0.05	0.16	0.13	0.09	0.19	0.10	0.19	0.12	0.09	0.20	0.15
A14	0.16	0.17	0.14	0.07	0.11	0.16	0.11	0.10	0.11	0.11	0.16	0.20	0.09	0.13	0.17
A15	0.21	0.23	0.21	0.23	0.23	0.22	0.21	0.20	0.23	0.23	0.21	0.20	0.22	0.22	0.22
A16	0.15	0.24	0.20	0.16	0.15	0.21	0.22	0.19	0.20	0.20	0.20	0.22	0.19	0.19	0.19
A17	0.21	0.20	0.20	0.24	0.15	0.20	0.20	0.20	0.22	0.13	0.20	0.23	0.22	0.21	0.13
A18	0.21	0.24	0.13	0.26	0.13	0.22	0.25	0.13	0.24	0.13	0.21	0.23	0.19	0.20	0.11
A19	0.16	0.22	0.24	0.14	0.10	0.15	0.22	0.16	0.19	0.10	0.15	0.20	0.14	0.18	0.10
A20	0.19	0.13	0.23	0.18	0.27	0.18	0.12	0.22	0.17	0.26	0.18	0.13	0.21	0.17	0.23
A21	0.20	0.13	0.18	0.05	0.13	0.18	0.10	0.16	0.05	0.13	0.18	0.12	0.16	0.06	0.13
A22	0.19	0.06	0.20	0.26	0.19	0.21	0.04	0.20	0.24	0.21	0.20	0.02	0.18	0.22	0.20
A23	0.24	0.23	0.24	0.20	0.27	0.23	0.23	0.23	0.18	0.25	0.21	0.23	0.22	0.19	0.24
A24	0.12	0.14	0.08	0.10	0.00	0.11	0.13	0.09	0.06	0.01	0.11	0.12	0.10	0.06	0.04
A25	0.19	0.15	0.22	0.25	0.25	0.18	0.11	0.22	0.21	0.23	0.17	0.12	0.21	0.18	0.23
A26	0.20	0.08	0.23	0.24	0.28	0.20	0.06	0.23	0.22	0.26	0.19	0.07	0.22	0.21	0.25
A27	0.23	0.22	0.20	0.18	0.24	0.23	0.23	0.21	0.17	0.20	0.23	0.23	0.17	0.16	0.19
A28	0.17	0.19	0.06	0.07	0.06	0.18	0.19	0.05	0.07	0.06	0.17	0.19	0.11	0.08	0.04
A29	0.22	0.24	0.22	0.26	0.21	0.23	0.24	0.22	0.24	0.22	0.21	0.22	0.19	0.23	0.24

Source: own processing

Table 2. Normalization (continued)

Alternatives	2021					2022					2023				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
A1	0.22	0.24	0.22	0.23	0.23	0.21	0.24	0.22	0.23	0.23	0.22	0.24	0.22	0.23	0.23
A2	0.19	0.24	0.14	0.14	0.15	0.18	0.24	0.14	0.16	0.14	0.19	0.23	0.13	0.15	0.13
A3	0.16	0.16	0.22	0.17	0.21	0.15	0.14	0.22	0.15	0.21	0.16	0.19	0.22	0.19	0.21
A4	0.12	0.09	0.17	0.14	0.12	0.12	0.11	0.18	0.16	0.13	0.12	0.08	0.18	0.15	0.15
A5	0.16	0.12	0.22	0.21	0.18	0.15	0.09	0.22	0.21	0.18	0.16	0.08	0.22	0.21	0.19
A6	0.18	0.24	0.17	0.24	0.22	0.20	0.22	0.15	0.23	0.22	0.20	0.18	0.15	0.23	0.21
A7	0.15	0.16	0.14	0.23	0.20	0.17	0.17	0.15	0.23	0.20	0.16	0.16	0.14	0.23	0.21
A8	0.11	0.08	0.17	0.13	0.13	0.11	0.17	0.16	0.14	0.13	0.11	0.14	0.20	0.13	0.15
A9	0.19	0.22	0.22	0.17	0.23	0.19	0.21	0.22	0.19	0.23	0.19	0.21	0.22	0.18	0.23
A10	0.24	0.19	0.21	0.22	0.21	0.24	0.18	0.21	0.22	0.22	0.23	0.21	0.21	0.21	0.22
A11	0.20	0.23	0.22	0.21	0.20	0.19	0.19	0.22	0.19	0.20	0.19	0.18	0.22	0.19	0.20
A12	0.21	0.25	0.22	0.20	0.23	0.20	0.22	0.19	0.19	0.22	0.21	0.25	0.21	0.21	0.23
A13	0.18	0.15	0.13	0.21	0.16	0.17	0.05	0.14	0.20	0.15	0.18	0.05	0.14	0.20	0.16
A14	0.17	0.21	0.07	0.14	0.17	0.15	0.09	0.07	0.13	0.17	0.15	0.09	0.07	0.12	0.17
A15	0.19	0.19	0.21	0.22	0.22	0.20	0.23	0.20	0.21	0.21	0.21	0.24	0.21	0.21	0.19
A16	0.18	0.19	0.17	0.19	0.19	0.20	0.20	0.16	0.18	0.18	0.20	0.24	0.16	0.18	0.20
A17	0.20	0.23	0.22	0.21	0.14	0.18	0.17	0.22	0.18	0.16	0.18	0.14	0.22	0.18	0.16
A18	0.20	0.24	0.18	0.17	0.07	0.20	0.23	0.18	0.17	0.10	0.20	0.24	0.18	0.15	0.09
A19	0.16	0.13	0.13	0.18	0.07	0.18	0.24	0.13	0.19	0.12	0.17	0.24	0.12	0.16	0.13
A20	0.17	0.10	0.20	0.17	0.21	0.17	0.14	0.20	0.15	0.20	0.15	0.15	0.22	0.17	0.14
A21	0.22	0.16	0.21	0.13	0.18	0.21	0.22	0.20	0.13	0.19	0.20	0.19	0.15	0.15	0.19
A22	0.20	0.03	0.17	0.22	0.19	0.20	0.02	0.16	0.22	0.21	0.20	0.03	0.17	0.21	0.22
A23	0.22	0.22	0.21	0.19	0.24	0.23	0.24	0.22	0.20	0.23	0.23	0.24	0.22	0.23	0.24
A24	0.15	0.20	0.17	0.07	0.06	0.14	0.19	0.21	0.15	0.06	0.15	0.17	0.21	0.16	0.13
A25	0.18	0.21	0.20	0.17	0.22	0.18	0.19	0.21	0.18	0.22	0.18	0.18	0.21	0.17	0.22
A26	0.19	0.06	0.22	0.21	0.24	0.19	0.05	0.21	0.20	0.23	0.20	0.11	0.21	0.20	0.15
A27	0.22	0.23	0.21	0.15	0.19	0.23	0.22	0.21	0.15	0.17	0.23	0.22	0.21	0.15	0.17
A28	0.16	0.17	0.10	0.12	0.04	0.15	0.17	0.14	0.16	0.04	0.15	0.18	0.14	0.16	0.07
A29	0.19	0.15	0.17	0.22	0.23	0.21	0.23	0.15	0.22	0.23	0.20	0.21	0.14	0.21	0.24

Source: own processing

Banks from Canada (A10), Spain (A23), and Turkey (A29) achieve the highest scores, indicating stronger ESG integration, whereas those from Belgium (A8), Colombia (A14), and the Netherlands (A24) record the lowest, reflecting gaps in ESG adoption (Elamer &

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Boulhaga, 2024). These differences underscore the need for region-specific strategies to enhance ESG-driven competitiveness in the knowledge economy.

Table 3 presents entropy-based weights (Formula 3), highlighting regional differences in ESG performance variability. Banks from Canada (A10) and Spain (A23) exhibit the highest values, indicating greater uncertainty and elevated ESG-related risks, whereas those from Belgium (A8) and Colombia (A14) show the lowest, reflecting more stable performance (Ragazou et al., 2025). These findings emphasize the value of entropy analysis in identifying performance instability and informing sustainability strategies.

Table 3. Entropy results

Alter-natives	2018					2019					2020				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
A1	-0.34	-0.34	-0.34	-0.33	-0.35	-0.34	-0.35	-0.34	-0.34	-0.35	-0.34	-0.34	-0.34	-0.34	-0.34
A2	-0.27	-0.34	-0.31	-0.16	-0.02	-0.29	-0.35	-0.30	-0.24	-0.28	-0.31	-0.34	-0.29	-0.27	-0.30
A3	-0.31	-0.30	-0.34	-0.32	-0.35	-0.31	-0.32	-0.34	-0.31	-0.34	-0.30	-0.29	-0.34	-0.30	-0.33
A4	-0.25	-0.24	-0.25	-0.20	-0.19	-0.26	-0.21	-0.24	-0.20	-0.19	-0.24	-0.21	-0.21	-0.23	-0.25
A5	-0.25	-0.30	-0.29	-0.27	-0.17	-0.25	-0.29	-0.34	-0.28	-0.18	-0.28	-0.29	-0.33	-0.33	-0.28
A6	-0.25	-0.17	-0.20	-0.22	-0.24	-0.27	-0.28	-0.26	-0.33	-0.31	-0.27	-0.33	-0.29	-0.34	-0.30
A7	-0.29	-0.33	-0.22	-0.31	-0.31	-0.28	-0.29	-0.28	-0.31	-0.32	-0.30	-0.29	-0.30	-0.34	-0.32
A8	-0.20	-0.14	-0.29	-0.26	-0.26	-0.21	-0.25	-0.29	-0.28	-0.23	-0.27	-0.27	-0.31	-0.27	-0.24
A9	-0.32	-0.34	-0.31	-0.33	-0.35	-0.31	-0.34	-0.30	-0.32	-0.34	-0.31	-0.34	-0.34	-0.30	-0.34
A10	-0.35	-0.32	-0.34	-0.35	-0.34	-0.35	-0.33	-0.34	-0.35	-0.34	-0.35	-0.32	-0.33	-0.34	-0.33
A11	-0.32	-0.34	-0.31	-0.32	-0.32	-0.32	-0.34	-0.31	-0.31	-0.32	-0.33	-0.34	-0.34	-0.32	-0.33
A12	-0.32	-0.31	-0.33	-0.33	-0.35	-0.32	-0.34	-0.34	-0.33	-0.34	-0.32	-0.34	-0.33	-0.34	-0.34
A13	-0.32	-0.26	-0.22	-0.30	-0.15	-0.29	-0.26	-0.22	-0.32	-0.24	-0.32	-0.26	-0.21	-0.32	-0.28
A14	-0.30	-0.30	-0.28	-0.19	-0.24	-0.29	-0.25	-0.23	-0.25	-0.24	-0.29	-0.32	-0.22	-0.27	-0.30
A15	-0.33	-0.34	-0.33	-0.34	-0.34	-0.33	-0.33	-0.32	-0.34	-0.34	-0.33	-0.32	-0.33	-0.33	-0.34
A16	-0.29	-0.34	-0.32	-0.30	-0.28	-0.32	-0.33	-0.32	-0.32	-0.32	-0.32	-0.33	-0.31	-0.32	-0.32
A17	-0.33	-0.32	-0.32	-0.34	-0.29	-0.32	-0.32	-0.32	-0.33	-0.27	-0.32	-0.34	-0.33	-0.33	-0.27
A18	-0.33	-0.34	-0.26	-0.35	-0.26	-0.33	-0.35	-0.27	-0.34	-0.27	-0.33	-0.34	-0.32	-0.32	-0.24
A19	-0.29	-0.33	-0.34	-0.28	-0.23	-0.29	-0.33	-0.29	-0.32	-0.23	-0.28	-0.32	-0.28	-0.31	-0.23
A20	-0.31	-0.26	-0.34	-0.31	-0.35	-0.31	-0.25	-0.34	-0.30	-0.35	-0.31	-0.26	-0.33	-0.30	-0.34
A21	-0.32	-0.26	-0.31	-0.16	-0.27	-0.31	-0.23	-0.29	-0.16	-0.26	-0.31	-0.26	-0.30	-0.16	-0.27
A22	-0.32	-0.16	-0.32	-0.35	-0.32	-0.33	-0.13	-0.32	-0.34	-0.33	-0.32	-0.09	-0.31	-0.33	-0.32
A23	-0.34	-0.34	-0.34	-0.32	-0.35	-0.34	-0.34	-0.34	-0.31	-0.35	-0.33	-0.34	-0.33	-0.32	-0.34
A24	-0.25	-0.28	-0.20	-0.24	-0.03	-0.24	-0.26	-0.22	-0.17	-0.04	-0.24	-0.26	-0.22	-0.16	-0.12
A25	-0.31	-0.29	-0.34	-0.35	-0.35	-0.31	-0.25	-0.33	-0.33	-0.34	-0.30	-0.26	-0.33	-0.31	-0.34
A26	-0.32	-0.20	-0.34	-0.34	-0.36	-0.32	-0.17	-0.34	-0.33	-0.35	-0.32	-0.18	-0.33	-0.33	-0.34
A27	-0.34	-0.33	-0.32	-0.31	-0.34	-0.34	-0.34	-0.33	-0.30	-0.32	-0.34	-0.34	-0.30	-0.29	-0.31
A28	-0.30	-0.32	-0.17	-0.18	-0.17	-0.31	-0.31	-0.16	-0.18	-0.16	-0.31	-0.32	-0.24	-0.21	-0.14
A29	-0.33	-0.34	-0.34	-0.35	-0.33	-0.34	-0.34	-0.33	-0.34	-0.33	-0.33	-0.33	-0.31	-0.34	-0.34

Source: own processing

Table 3. Entropy results (continued)

Alter-natives	2021					2022					2023				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
A1	-0.33	-0.34	-0.33	-0.34	-0.34	-0.33	-0.34	-0.33	-0.34	-0.34	-0.33	-0.34	-0.33	-0.34	-0.34
A2	-0.31	-0.34	-0.27	-0.27	-0.28	-0.31	-0.34	-0.27	-0.29	-0.27	-0.31	-0.34	-0.26	-0.28	-0.27
A3	-0.29	-0.29	-0.33	-0.30	-0.33	-0.29	-0.28	-0.33	-0.28	-0.33	-0.29	-0.31	-0.33	-0.32	-0.33
A4	-0.26	-0.22	-0.30	-0.27	-0.26	-0.25	-0.25	-0.31	-0.29	-0.27	-0.26	-0.20	-0.31	-0.28	-0.28
A5	-0.30	-0.25	-0.33	-0.33	-0.31	-0.28	-0.21	-0.33	-0.32	-0.31	-0.30	-0.20	-0.33	-0.33	-0.31
A6	-0.31	-0.34	-0.30	-0.34	-0.33	-0.32	-0.33	-0.29	-0.34	-0.33	-0.32	-0.31	-0.29	-0.34	-0.33
A7	-0.28	-0.29	-0.27	-0.34	-0.32	-0.30	-0.30	-0.29	-0.34	-0.32	-0.30	-0.29	-0.27	-0.34	-0.33
A8	-0.24	-0.20	-0.30	-0.27	-0.27	-0.25	-0.30	-0.29	-0.28	-0.27	-0.24	-0.28	-0.32	-0.27	-0.29
A9	-0.32	-0.33	-0.33	-0.30	-0.34	-0.32	-0.33	-0.33	-0.31	-0.34	-0.32	-0.33	-0.33	-0.31	-0.34
A10	-0.34	-0.32	-0.33	-0.34	-0.33	-0.34	-0.31	-0.33	-0.33	-0.33	-0.34	-0.33	-0.33	-0.33	-0.33
A11	-0.32	-0.34	-0.33	-0.33	-0.32	-0.32	-0.32	-0.33	-0.32	-0.32	-0.31	-0.31	-0.33	-0.31	-0.32
A12	-0.33	-0.35	-0.33	-0.32	-0.34	-0.32	-0.33	-0.32	-0.32	-0.34	-0.33	-0.35	-0.33	-0.33	-0.34
A13	-0.31	-0.28	-0.26	-0.33	-0.29	-0.30	-0.16	-0.28	-0.32	-0.29	-0.31	-0.16	-0.28	-0.32	-0.29
A14	-0.30	-0.33	-0.19	-0.27	-0.30	-0.28	-0.22	-0.19	-0.27	-0.30	-0.28	-0.21	-0.19	-0.26	-0.30
A15	-0.32	-0.32	-0.33	-0.33	-0.33	-0.32	-0.34	-0.32	-0.33	-0.33	-0.33	-0.34	-0.33	-0.33	-0.32
A16	-0.31	-0.32	-0.30	-0.31	-0.31	-0.32	-0.32	-0.30	-0.31	-0.31	-0.32	-0.34	-0.29	-0.31	-0.32
A17	-0.32	-0.34	-0.33	-0.33	-0.27	-0.31	-0.30	-0.33	-0.31	-0.29	-0.31	-0.27	-0.33	-0.31	-0.29
A18	-0.32	-0.34	-0.31	-0.30	-0.19	-0.32	-0.34	-0.31	-0.30	-0.23	-0.32	-0.34	-0.31	-0.29	-0.22
A19	-0.29	-0.27	-0.27	-0.31	-0.19	-0.31	-0.34	-0.26	-0.32	-0.25	-0.30	-0.34	-0.25	-0.29	-0.27
A20	-0.30	-0.24	-0.32	-0.30	-0.33	-0.30	-0.28	-0.32	-0.29	-0.32	-0.29	-0.28	-0.33	-0.30	-0.28
A21	-0.33	-0.29	-0.33	-0.27	-0.31	-0.33	-0.33	-0.32	-0.27	-0.32	-0.32	-0.32	-0.28	-0.29	-0.32
A22	-0.32	-0.09	-0.30	-0.33	-0.32	-0.32	-0.09	-0.30	-0.33	-0.33	-0.32	-0.09	-0.30	-0.33	-0.33
A23	-0.33	-0.33	-0.33	-0.31	-0.34	-0.34	-0.34	-0.33	-0.32	-0.34	-0.34	-0.34	-0.33	-0.34	-0.34

Alter-natives	2021					2022					2023				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
A24	-0.28	-0.32	-0.30	-0.19	-0.17	-0.27	-0.32	-0.33	-0.28	-0.17	-0.29	-0.30	-0.33	-0.30	-0.27
A25	-0.31	-0.33	-0.32	-0.30	-0.33	-0.31	-0.31	-0.33	-0.31	-0.33	-0.31	-0.31	-0.33	-0.30	-0.33
A26	-0.31	-0.17	-0.33	-0.33	-0.34	-0.32	-0.16	-0.33	-0.32	-0.34	-0.32	-0.24	-0.33	-0.32	-0.29
A27	-0.34	-0.34	-0.33	-0.29	-0.31	-0.34	-0.33	-0.33	-0.29	-0.30	-0.34	-0.33	-0.33	-0.29	-0.30
A28	-0.30	-0.30	-0.23	-0.26	-0.12	-0.29	-0.30	-0.27	-0.30	-0.13	-0.28	-0.31	-0.27	-0.29	-0.18
A29	-0.32	-0.28	-0.30	-0.33	-0.34	-0.33	-0.34	-0.29	-0.33	-0.34	-0.32	-0.33	-0.27	-0.33	-0.34

Source: own processing

Table 4 presents the positive (V^+) and negative (V^-) ideal solutions for OECD banks (Formula 5), derived from entropy-weighted and normalized ESG indicators (C1–C5) (Formula 4). This approach reflects the relative importance of each ESG dimension and provides an objective assessment of ESG competitiveness.

Table 4. Positive and negative ideal solutions

Alternatives	2018					2019					2020				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
v+j	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00
v-j	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01

Source: own processing

Table 4. Positive and negative ideal solutions (continued)

Alternatives	2021					2022					2023				
	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5	C1	C2	C3	C4	C5
v+j	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00	0.01	0.01	0.01	0.00	0.00
v-j	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01	0.00	0.00	0.00	0.01	0.01

Source: own processing

The ideal benchmarks indicate that top performers achieve strong results in ESG, shareholder, and CSR strategy scores (C1–C3), alongside lower emissions and resource use (C4–C5) (Yuen et al., 2022), whereas underperformers exhibit weaker ESG integration and higher environmental impacts (Elamer & Boulhaga, 2024). These findings highlight the need to improve environmental efficiency and sustainability management in the knowledge economy.

Table 5 reports the positive (S_i^+) and negative (S_i^-) distances (Formula 6) and the relative closeness (C_i) derived from the TOPSIS method (Formula 7). The Austrian bank (A2) achieves the highest score (0.65), indicating strong ESG alignment and sustainability management (Menicucci & Paolucci, 2023), whereas the Portuguese bank (A22) records the lowest (0.34), reflecting weaker ESG integration (Dadabada, 2025). These disparities highlight the need for region-specific sustainability strategies to enhance competitiveness in the knowledge economy.

Table 5. The closeness coefficient s+, s- and rank

Alternatives	S_i^+	S_i^-	C_i	Rank	Alternatives	S_i^+	S_i^-	C_i	Rank
A1	0.02	0.02	0.54	12	A16	0.02	0.02	0.55	10
A2	0.01	0.02	0.65	**1**	A17	0.02	0.02	0.58	8
A3	0.02	0.02	0.49	19	A18	0.01	0.02	0.63	2
A4	0.02	0.02	0.48	20	A19	0.01	0.02	0.59	7
A5	0.02	0.02	0.50	17	A20	0.02	0.02	0.46	24
A6	0.02	0.02	0.44	25	A21	0.01	0.02	0.60	6
A7	0.02	0.01	0.41	27	**A22**	0.03	0.01	0.34	**29**
A8	0.02	0.02	0.47	22	A23	0.02	0.02	0.55	11
A9	0.02	0.02	0.52	15	A24	0.02	0.02	0.60	5
A10	0.02	0.02	0.52	14	A25	0.02	0.02	0.47	23
A11	0.02	0.02	0.55	9	A26	0.02	0.02	0.39	28
A12	0.02	0.02	0.53	13	A27	0.01	0.02	0.61	4
A13	0.02	0.01	0.42	26	A28	0.01	0.02	0.62	3
A14	0.02	0.02	0.48	21	A29	0.02	0.02	0.49	18
A15	0.02	0.02	0.52	16					

Source: own processing

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The robustness of the ranking results was evaluated using Monte Carlo simulation and bootstrap resampling (Table 6). The Monte Carlo weight-perturbation analysis indicated strong stability, with a high average Spearman correlation (ρ = 0.9764) and low rank variability (1.6137); the top-ranked bank consistently retained its position across all 1,000 simulations.

Table 6. Robustness check and sensitivity analyses

Method	Metric	Result	Interpretation
Monte Carlo	Avg. Spearman ρ vs. Initial	0.9764	Higher values indicate stronger agreement between initial and perturbed rankings.
Monte Carlo	Rank Variability (Avg. Std Dev)	1.6137	Lower values indicate more stable ranks across perturbations.
Monte Carlo	Max First-Place Frequency	1000	Indicates the highest frequency a company achieved rank 1.
Bootstrap	Avg. Spearman ρ vs. Initial	0.9685	Higher values indicate stronger agreement between initial and resampled rankings.
Bootstrap	Rank Variability (Avg. Std Dev)	2.0209	Lower values indicate more stable ranks across perturbations.
Bootstrap	Max First-Place Frequency	975	Indicates the highest frequency a company achieved rank 1.

Source: own processing

Bootstrap resampling further confirmed reliability, yielding a high average Spearman correlation (ρ = 0.9685) and low rank variability (2.0209), with the top-ranked bank remaining first in 975 out of 1,000 samples. Additionally, a t-test produced a non-significant result (p = 1), indicating no meaningful difference between the original and modified data.

These findings provide strong evidence of the robustness, stability, and low sensitivity of the ESG-based competitiveness rankings to weighting assumptions. The overall rankings are presented in Figure 3.

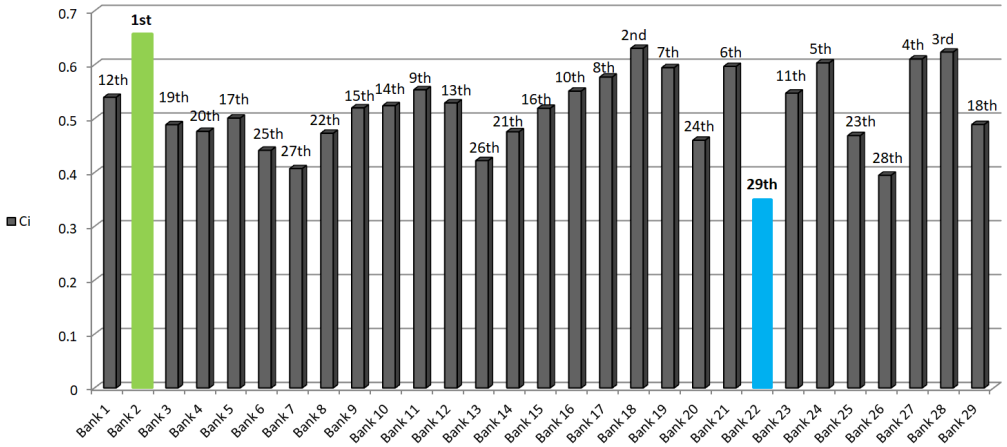

Figure 3. Overall ranking of top bank in OECD countries

Source: own processing

Figure 4 compares Austrian and Portuguese banks across ESG dimensions (C1–C5). The Austrian bank demonstrates weaker social and governance performance within ESG (C1) despite strong environmental practices, whereas the Portuguese bank benefits from stronger social engagement. In Shareholder Score (C2), Austria exhibits stronger governance and shareholder alignment, while Portugal is constrained by fragmented ownership. In CSR Strategy (C3), the Austrian bank emphasizes environmental initiatives but shows weaker community engagement, whereas the Portuguese bank performs better in socially oriented CSR. In Emissions (C4) and Resource Use (C5), the Austrian bank leads

due to proactive environmental policies and advanced infrastructure, while the Portuguese bank lags because of structural and regulatory constraints.

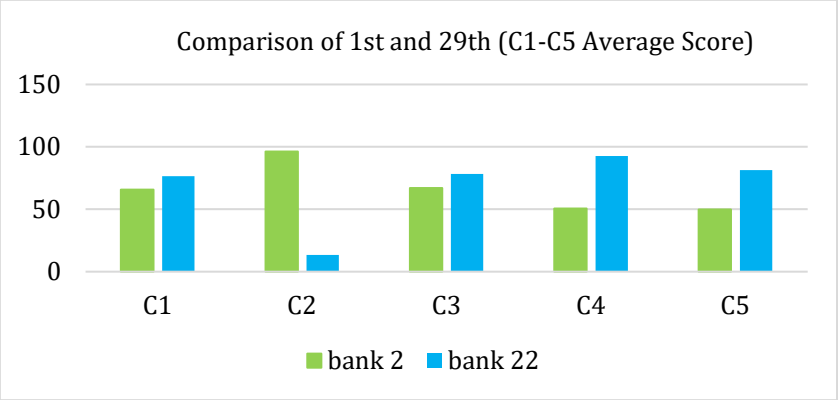

Figure 4. Average score comparison of the top rank and the lowest rank bank in OECD countries. Note. C4 and C5: Lower scores indicate better performance
Source: own processing

These differences highlight contrasting sustainability approaches and their implications for ESG-driven competitiveness in the knowledge economy.

Figure 5 illustrates the evolving competitiveness of Austrian and Portuguese banks from 2018 to 2023 across five sustainability dimensions (C1–C5), highlighting distinct regional trajectories. In ESG Score (C1), the Austrian bank shows steady improvement, peaking in 2023, reflecting effective ESG integration under regulatory reform, whereas the Portuguese bank performs strongly in social metrics, peaking in 2022. In Shareholder Score (C2), the Austrian bank demonstrates governance maturity, reaching a 2023 peak, while the Portuguese bank shows gradual improvement despite structural constraints. In CSR Strategy (C3), the Austrian bank exhibits a consistent, regulation-driven approach, whereas the Portuguese bank displays a more socially oriented but less integrated strategy. In Emissions (C4) and Resource Use (C5), the Austrian bank leads, supported by early green finance adoption and strong regulatory frameworks, while the Portuguese bank lags due to slower structural and policy development, despite recent progress.

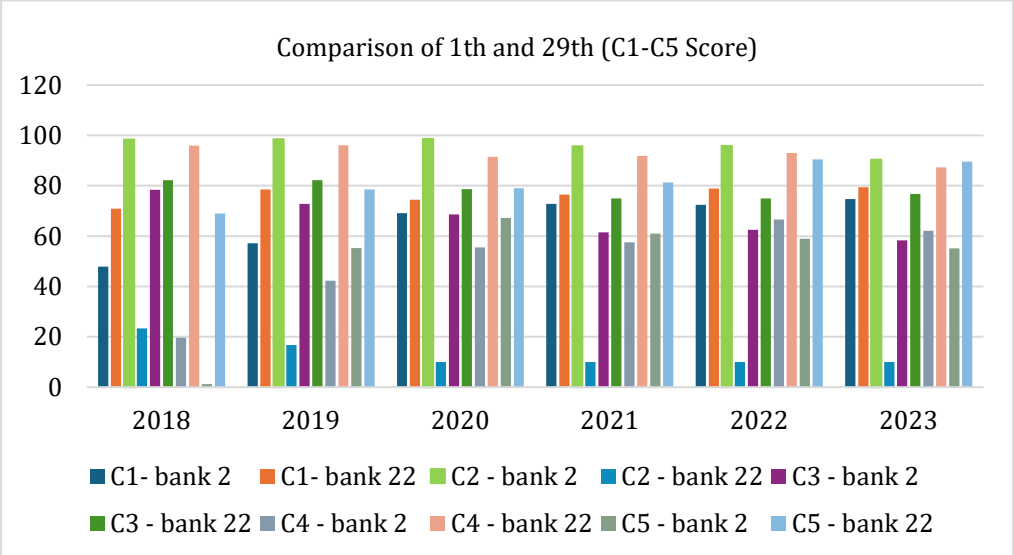

Figure 5. Comparison of the top rank and the lowest rank of OECD countries
Source: own processing

Overall, these patterns reveal distinct regional sustainability pathways and their implications for competitiveness in the knowledge economy.

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Conclusions and future directions

This study provides a comprehensive assessment of ESG performance within the OECD banking sector, demonstrating that disaggregated indicators, particularly shareholder score (C2), emissions score (C4), and resource use score (C5), offer more precise insights into sustainability management and competitiveness than aggregated ESG measures. The findings confirm that targeted governance and environmental practices are closely associated with improved institutional performance, supporting evidence from prior research (Horobet et al., 2025). Rather than relying solely on composite ESG indicators, the results emphasize the importance of criterion-specific evaluations that reflect differences in institutional contexts and regulatory environments across OECD countries. Although aggregated ESG (C1) and CSR strategy (C3) indicators remain important, they do not consistently correlate with higher competitiveness across all regions. Instead, the analysis reveals that shareholder engagement, emissions control, and resource efficiency exert stronger and more direct influences on ESG-driven competitiveness. Simultaneously, the results confirm that robust ESG disclosures and CSR strategies continue to play essential roles in enhancing banking performance and stakeholder trust (Lamanda & Tamásné Vőneki, 2024). Overall, the findings reinforce the theoretical foundations of sustainable development and stakeholder-oriented value creation, demonstrating that long-term competitiveness in the knowledge economy is better captured through dimension-specific ESG capabilities.

Strategic implications for policymakers

The results offer valuable insights for policymakers aiming to enhance sustainable finance and ESG-driven competitiveness within the OECD banking sector. Regulatory authorities should move beyond aggregated ESG indicators and promote criterion-specific sustainability frameworks, particularly focusing on governance, emissions, and resource management. Given the observed regional disparities, policymakers in organizations such as the OECD and the United Nations should develop region-sensitive ESG policies that account for differences in institutional capacity, economic structure, and environmental priorities. These approaches can foster more balanced and effective sustainability management across diverse banking systems.

Implications for businesses

For banking institutions, the findings underscore the strategic importance of focusing on specific ESG dimensions to enhance competitiveness. Managers should prioritize improvements in shareholder alignment, emissions reduction, and resource efficiency, as these areas exhibit stronger correlations with performance outcomes. The comparative analysis also reveals that banks in different regions excel in distinct ESG dimensions, indicating that peer benchmarking and context-specific sustainability strategies can help institutions strengthen weaker areas without compromising their core strengths. These insights support more informed, knowledge-based strategic decision-making within the banking sector.

Implications for researchers

This study contributes a knowledge-oriented, data-driven framework for evaluating ESG-based competitiveness across countries in academic research. By integrating the entropy–TOPSIS method, it provides an objective approach to weighting ESG criteria and ranking institutions according to their relative sustainability performance. This methodological contribution supports future research on sustainable finance, ESG performance, and competitiveness within the knowledge economy, especially in cross-country and multi-industry contexts.

Limitations and future directions

Several limitations should be acknowledged. First, the study focuses exclusively on the OECD banking sector, which may limit the generalizability of the findings to emerging or non-OECD economies. Future research could extend the analysis to include a broader range of countries and financial systems. Second, data availability varies across some OECD countries, and the selected ESG indicators may not fully capture the complexity of sustainability practices. Third, the analysis covers a six-year period ending in 2023; future studies could incorporate longer time horizons to better capture structural trends.
Finally, the study employs the entropy-TOPSIS approach, which, although objective and transparent, represents only one methodological perspective. Future research could apply alternative techniques, such as machine learning, panel econometric models, or longitudinal analyses, to further investigate ESG-driven competitiveness. Expanding methodological diversity would provide deeper insights into the evolving dynamics of sustainable finance within the knowledge economy.

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Appendix

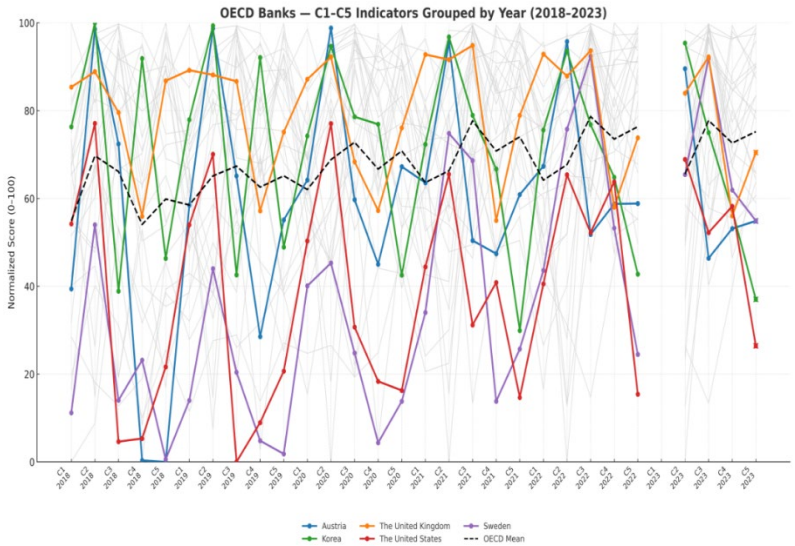

Figure A1. OECD Bank ESG Score
Source: own processing