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A sorting-based multicriteria decision model for ESG screening of sovereign investment assets

Juan Antonio Granados Montelongo[1], Alberto Aguilera[2], Francisco Magallanes[3], Juan Antonio Álvarez Gaona[4], José Daniel Corona Flores[5], Abril Flores[6*]

[1]Department of Renewable Natural Resources, Antonio Narro Autonomous Agrarian University, Mexico; juan.granados@uaaan.edu.mx (J.A.G.M.).
[2]Faculty of Political and Social Sciences, Autonomous University of Chihuahua, Mexico; albertoat356@gmail.com (A.A.).
[3]Torreón Technological Institute, National Technological Institute of Mexico, Mexico; jesus.ma@torreon.tecnm.mx (F.M.).
[4]Faculty of Marketing, Autonomous University of Coahuila, Mexico; antonio_alvarezgaona@uadec.edu.mx (J.A.A.G.).
[5]Academic Language Unit, Antonio Narro Autonomous Agrarian University, Mexico; dcorona@uaaan.edu.mx (J.D.C.F.).
[6]Faculty of Accounting and Administration, Autonomous University of Coahuila, Mexico; artemisaflores@uadec.edu.mx (A.F.)

Abstract: The rapid growth of sustainable finance has increased the need for transparent and robust decision-support tools for screening environmental, social, and governance (ESG) investment assets. Conventional ESG evaluation methods often rely on composite scores that obscure trade-offs among criteria and inadequately address data imprecision and heterogeneity. This paper proposes a hierarchical interval outranking approach for classifying sustainable finance assets into acceptability categories, rather than producing a full ranking. The method structures ESG criteria hierarchically and represents performance evaluations using intervals to explicitly account for uncertainty, variability, and incomplete information commonly observed in ESG datasets. An outranking-based sorting procedure is then applied to assign assets to predefined classes, such as non-acceptable, acceptable, and priority investments. The framework is demonstrated using publicly available ESG indicators for countries, interpreted as sovereign investment assets, illustrating its ability to deliver transparent, non-compensatory classifications while maintaining interpretability at each aggregation level. The results show that the approach supports consistent and explainable ESG screening decisions, offering a viable alternative to opaque scoring-based methods. The proposed model contributes to sustainable finance research by integrating hierarchical multicriteria decision analysis with interval-based uncertainty handling and provides practical value for portfolio managers and policymakers engaged in responsible investment decision-making.

Keywords: *ESG screening, Multicriteria decision analysis, Sovereign investment assets.*

1. Introduction

The integration of environmental, social, and governance (ESG) considerations into investment decision-making has become a defining feature of contemporary finance. Driven by regulatory pressures, stakeholder expectations, and growing evidence of the financial relevance of sustainability factors, investors increasingly rely on ESG information to screen, select, and manage assets within sustainable investment portfolios. As a result, sustainable finance has evolved from a niche practice into a mainstream component of financial markets, encompassing instruments such as green bonds, ESG-oriented funds, and sustainability-linked investment strategies. In addition to corporate securities, ESG considerations are increasingly applied to sovereign investment assets, such as government bonds and country-based exchange-traded funds, where countries represent the fundamental units of sustainability-related risk and opportunity.

* Correspondence: artemisaflores@uadec.edu.mx

Despite this rapid expansion, ESG-based investment decision-making faces persistent methodological challenges. A central issue concerns the evaluation and aggregation of heterogeneous ESG criteria, which are inherently multidimensional and often organized in layered structures. Environmental performance, social responsibility, and governance quality each comprise multiple subdimensions that differ in scale, relevance, and measurability. Moreover, ESG data are frequently characterized by uncertainty, incompleteness, and temporal variability, arising from differences in reporting standards, estimation methods, and data sources. These characteristics limit the effectiveness and credibility of conventional evaluation approaches.

Most existing ESG assessment frameworks rely on composite scores or weighted averages that aggregate criteria into a single index. While such approaches are convenient, they suffer from several well-documented limitations. First, compensatory aggregation allows poor performance in one ESG dimension to be offset by strong performance in another, potentially masking critical weaknesses that are particularly relevant in sovereign risk contexts. Second, the construction of composite scores often lacks transparency, reducing interpretability and trust among investors and policymakers. Third, point-valued scores fail to adequately capture uncertainty and variability in ESG indicators, leading to potentially misleading precision in asset evaluations.

From a decision-analytic perspective, many sustainable finance problems, particularly those involving the eligibility of sovereign investment assets, are better framed as screening or sorting tasks rather than ranking exercises. In practice, investors, portfolio managers, and supervisory authorities are often interested in classifying assets into acceptability categories, such as non-acceptable, acceptable, or priority investments, based on minimum sustainability requirements and strategic objectives. This perspective aligns naturally with multicriteria sorting methods, which are designed to handle non-compensatory reasoning, incomparability, and partial preference information.

Outranking-based multicriteria decision analysis (MCDA) methods, such as those developed within the ELECTRE family, offer a theoretically sound foundation for ESG asset screening. These methods compare alternatives pairwise across multiple criteria and determine whether there is sufficient evidence to assert that one alternative is at least as good as another. When extended to hierarchical criteria structures, outranking approaches enable the explicit modeling of ESG dimensions and subdimensions while preserving preference information at different levels of aggregation. Furthermore, the incorporation of interval-valued evaluations provides a principled way to represent uncertainty, variability, and imprecision in ESG data without resorting to arbitrary point estimates.

Against this background, this paper proposes a hierarchical interval outranking framework for screening sustainable finance assets, focusing on countries as sovereign investment assets. The approach combines three key features: (i) a hierarchical representation of ESG criteria, (ii) interval-valued performance evaluations to explicitly capture data uncertainty, and (iii) an outranking-based sorting procedure that assigns alternatives to predefined acceptability classes. By emphasizing classification over ranking, the method aligns closely with real-world sustainable investment practices and regulatory screening requirements.

The contribution of this study is twofold. From a methodological standpoint, it advances the application of hierarchical outranking models in sustainable finance by integrating interval-valued data into ESG-based screening decisions. From a practical standpoint, it provides a transparent and replicable decision-support framework that can be implemented using publicly available international datasets, enhancing the robustness and interpretability of sovereign ESG investment assessments. The remainder of the paper is organized as follows. Section 2 reviews the related literature on ESG evaluation and multicriteria decision methods in sustainable finance. Section 3 presents the proposed materials and methods. Section 4 illustrates the application of the framework using country-level ESG indicators. Section 5 discusses the results and implications, and Section 6 concludes with directions for future research.

2. Literature Review

Sustainable finance has transitioned from a niche strategy to a mainstream segment of capital markets, with investors increasingly integrating ESG criteria into product design, portfolio construction, and eligibility screening. Market reports and policy analyses highlight the growth of sustainable instruments and ongoing concerns about credibility and greenwashing, which drive the need for more transparent and auditable screening frameworks (European Supervisory Authorities, 2024; United Nations Conference on Trade, 2024). A practical implication is that many ESG decisions are operationally framed as sorting problems (e.g., eligible vs. non-eligible, compliant vs. non-compliant, "priority" vs. "acceptable"), rather than continuous ranking. This screening logic is reinforced by regulatory regimes that differentiate product categories and disclosures, making *classification* a natural decision output for asset managers and supervisors (European Supervisory Authorities, 2024; European Union, 2019).

A central methodological challenge in ESG investing is that the underlying data is noisy, incomplete, and often inconsistent across providers. A widely cited empirical finding is the substantial divergence of ESG ratings across major rating agencies, driven by differences in (i) scope, (ii) measurement, and (iii) weighting choices. This divergence introduces uncertainty into decisions based on ESG scores and undermines comparability across assets (Berg, Kölbel, & Rigobon, 2022).

Beyond divergence, recent work continues to document black-box concerns: ESG scoring methodologies may not fully disclose inputs, transformations, and aggregation rules, which weaken interpretability and raise reliability concerns for high-stakes investment decisions (Balan, Antunes, Wanke, Tan, & Gerged, 2025). The rating-disagreement problem has also been operationalized directly in portfolio selection research. Recent studies treat ESG assessment as a multicriteria problem alongside risk and return, explicitly addressing rating disagreement as an input uncertainty issue that can alter portfolio outcomes and investment conclusions (Berg et al., 2022).

Regulatory and supervisory developments in the EU have increased the importance of clear screening logic. The Sustainable Finance Disclosure Regulation (SFDR) establishes sustainability-related disclosure obligations and product-level distinctions, which are associated with classification-based market behavior (e.g., Article 8 vs. Article 9 categorizations of the Ritchie, Rosado, and Roser (2023). However, legal and empirical literature warns that definitional breadth and classification incentives may create greenwashing risks. Greenwashing refers to presenting investments or financial alternatives as ESG attractive when they are not. Evidently, greenwashing can hinder the achievement of objectives investors set for sustainable or green investments. Legal analysis has specifically discussed the misapplication and misuse of SFDR Articles 8 and 9 as channels through which greenwashing can emerge (Varsi, 2023). Empirical work has begun testing whether SFDR mitigates greenwashing, including evidence consistent with reduced greenwashing for certain fund categories under post-SFDR conditions, noting that results depend on measurement choices and identification strategies (Abouarab, Mishra, & Wolfe, 2025).

Supervisors have proposed reforms and clearer product categories to reduce misuse and enhance investor understanding. The Joint Opinion by the European Supervisory Authorities (EBA, EIOPA, ESMA) explicitly frames category redesign as a response to greenwashing concerns and consumer confusion (European Supervisory Authorities, 2024).

MCDA is increasingly used in business and finance contexts where decisions are multidimensional, preferences are partially articulated, and trade-offs should not be fully compensatory. An authoritative reference entry specifically focused on MCDA for corporate responsibility and sustainable investments frames the field as a natural methodological home for ESG evaluation, given the plurality of criteria and stakeholder-dependent importance weights (Fernández et al., 2023; López et al., 2023; Solares et al., 2025). In finance, ESG integration is frequently studied via multi-objective frameworks that embed ESG alongside risk and return, reflecting the decision reality of investors balancing financial and sustainability goals. Recent contributions continue to develop robust preference-based or uncertainty-aware models for ESG integration in portfolio selection. Empirical finance work also examines the consequences of screening thresholds and the diversification trade-off, reinforcing the practical need for screening tools that are transparent about the classification logic and its financial implications (Solares, De-Leon-Gomez, Salas, & Díaz, 2022; Solares, Salas, De-Leon-Gomez, & Díaz, 2022).

A key limitation of composite ESG scores and additive aggregation is compensability, whereby strong performance on one pillar may offset unacceptable performance on another. Outranking methods, notably ELECTRE-family models, are often chosen when decision-makers seek (i) non-compensatory reasoning, (ii) the ability to represent incomparability, and (iii) explicit modeling of veto/discordance effects, properties aligning closely with ESG screening, where "red flags" should not be overshadowed by strengths elsewhere (Navarro, Fernández, Solares, Flores, & Díaz, 2023). Sorting variants like ELECTRE TRI are widely discussed as tools for assigning alternatives to ordered categories rather than producing total rankings, matching the operational logic of ESG eligibility screening. Formal developments in the ELECTRE TRI family, including newer variants, provide theoretical and practical foundations for category-based assignments (Diaz, Fernández, Figueira, Navarro, & Solares, 2024).

For ESG in particular, two additional requirements are common: (1) hierarchical criteria, because E–S–G naturally decomposes into subdimensions; and (2) uncertainty representation, because ESG indicators vary over time and across providers. The Multiple Criteria Hierarchy Process (MCHP) has been proposed to address hierarchical structuring in ELECTRE TRI-style sorting problems, supporting coherent aggregation across levels of the criteria tree (Corrente, Greco, & Słowiński, 2016).

Finally, recent work demonstrates that hierarchical outranking frameworks can be used in ESG contexts to produce transparent evaluations, such as in sovereign ESG assessment using an MCHP–ELECTRE–SMAA approach, explicitly acknowledging data inconsistencies and scenario-based weights, features aligned with interval and robust screening designs for assets (Xidonas, Corrente, Samitas, & Lekkos, 2025).

3. Materials and Methods

This section describes the data and methodological framework used to screen sovereign investment assets based on ESG considerations. It explains how countries are modeled as decision alternatives, how ESG criteria and indicators are selected from publicly available databases, and how a hierarchical interval outranking approach is applied to classify countries into ESG acceptability categories under uncertainty.

3.1. Decision Context and Problem Definition

Here, countries are considered decision alternatives, representing sovereign exposure relevant for investment instruments such as government bonds, country exchange-traded funds, and internationally diversified portfolios.

Rather than producing a complete ranking of countries, the objective is to classify sovereign investment assets into predefined ESG acceptability categories. This approach reflects practical decision processes in sustainable finance, where countries are often screened as eligible or non-eligible for ESG-oriented investment strategies or prioritized according to sustainability thresholds.

Let

$$A = (a_1, a_2, \ldots, a_n)$$

denote the set of countries under analysis. Each country a_i is to be assigned to one ordered category

$$C = (C_1, C_2, \ldots, C_k),$$

where categories range from low to high ESG acceptability (e.g., non-acceptable, acceptable, priority).

3.2. ESG Criteria for Assessing Sovereign Assets

The assessment of sovereign investment assets employs a hierarchical ESG criteria structure that captures the multidimensional and layered aspects of sustainability performance at the country level.

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This hierarchy ensures conceptual coherence, data availability, and relevance for sustainable finance decision-making, while remaining compatible with an outranking-based sorting framework.
At the highest level, the hierarchy consists of the three widely accepted ESG pillars:

- Environmental (E)
- Social (S)
- Governance (G)

These pillars represent distinct and non-substitutable dimensions of sustainability-related risk and opportunity for sovereign investment assets.

3.2.1. Environmental Dimension (E)

The environmental pillar measures how a country's economic activity aligns with long-term environmental sustainability and climate goals. It indicates exposure to transition and physical risks, which are increasingly significant for sovereign investors.

This pillar is decomposed into the following criteria:

1. *CO_2 emissions per capita* (E_1)
   Measures the average carbon footprint associated with economic and social activity. High emissions per capita indicate greater exposure to climate transition risks and potential future policy constraints.
2. *Renewable energy consumption* (E_2)
   Captures the share of energy derived from renewable sources in total final energy consumption. Higher values indicate progress toward decarbonization and reduced dependence on fossil fuels.
3. *Energy intensity of GDP* (E_3)
   Measures the amount of energy used per unit of economic output. Lower energy intensity reflects greater efficiency and lower environmental pressure per unit of value created.

3.2.2. Social Dimension (S)

The social pillar reflects the quality of human capital, social cohesion, and distributional outcomes within a country. These factors are closely linked to long-term economic resilience, political stability, and inclusive growth.
This pillar is evaluated using the following criteria:

1. *Life expectancy at birth* (S_1)
   Serves as a synthetic indicator of population health, healthcare access, and living conditions.
2. *Educational attainment* (S_2)
   Captures the level of human capital formation and the workforce's capacity to support sustainable economic development.
3. *Income inequality* (S_3)
   Measured through the Gini coefficient, this criterion reflects the degree of income dispersion and potential social tensions that may affect long-term stability.

3.2.3. Governance Dimension (G)

The Governance pillar captures the quality of institutions, policy implementation capacity, and rule-based decision-making. In sovereign investment contexts, governance is often considered a critical or non-compensatory dimension, as weaknesses in governance can undermine environmental and social achievements.
The following criteria are included:

1. *Government effectiveness* (G_1)
   Measures the quality of public services, policy formulation, and implementation.
2. Regulatory quality (G_2)

Captures the government's ability to design and implement sound policies and regulations that support private sector development.

3. *Control of corruption* (G_3)
   Reflects the extent to which public power is exercised for private gain, including both petty and grand corruption.

The three ESG pillars form the intermediate level of the hierarchy, while the nine criteria listed above constitute the elementary (leaf-level) criteria used for performance evaluation. The hierarchical structure enables:

- Clear separation of ESG dimensions,
- Aggregation of preferences within pillars before cross-pillar comparison,
- Application of non-compensatory logic at both pillar and global levels.

3.3. Criteria Scores and Indicators of Sovereign Investment Assets

3.3.1. Decision Alternatives: Countries as Sovereign Investment Assets

Here, countries are treated as decision alternatives (sovereign investment assets). Each country's "performance" is represented by a vector of ESG-related indicators drawn from internationally curated databases. This is how sovereign ESG is screened in practice, where investors compare cross-country exposures to environmental risks, social development outcomes, and institutional quality, then classify sovereigns into eligibility or priority classes for portfolio inclusion (e.g., eligible, watchlist, excluded). Formally, let $A = (a_1, \ldots, a_n)$ be the set of countries. For each country a_i, the criteria score vector is

$$\mathrm{x}(a_i) = (x_{E1}(a_i), x_{E2}(a_i), x_{E3}(a_i), x_{S1}(a_i), x_{S2}(a_i), x_{S3}(a_i), x_{G1}(a_i), x_{G2}(a_i), x_{G3}(a_i)),$$

where the criteria follow the fixed ESG hierarchy defined in Section 3.2.

3.3.2. Data Sources, Update Policy, and Traceability Controls

Our main sources are the World Bank, Our World in Data (OWID), the Organization for Economic Co-operation and Development (OECD), and the United Nations Sustainable Development Goals (UN SDG). The primary principle followed in this work is that direct observability and replicability must always be present; therefore, criteria scores are taken from openly accessible repositories that provide country-series data with transparent provenance and periodic revision policies. Furthermore, since World Development Indicators and Worldwide Governance Indicators (from the World Bank) can be revised (methodological changes, backfilled values, and corrections), we explicitly track update guidance and errata from the World Bank's Data Help Desk (World Bank, 2025). We rely on processed datasets (e.g., Our World in Data), and we use their published "Sources & Processing" documentation to ensure the indicator definition matches the intended construct and to preserve citation integrity (Our World in Data, 2025a; Ritchie et al., 2023).

3.3.3. Indicator Mapping to the Sovereign ESG Criteria Hierarchy

The criteria hierarchy (Section 3.2) is operationalized using indicators as follows. All indicators are country-level, numeric, and comparable across alternatives.

3.3.3.1. Environmental Pillar (E)

- E_1 — Carbon emissions per capita (tons/person). Indicator: CO_2 emissions per capita (territorial fossil and industrial emissions), unit: tonnes per person. Database: Our World in Data (based on Global Carbon Budget; population sources as documented) (Ritchie et al., 2023).
- E_2 — Renewable energy in final consumption (%). Indicator: Renewable energy consumption (% of total final energy consumption), typically the World Bank WDI code EG.FEC.RNEW.ZS (direct from WDI) (World Bank, 2025).
- E_3 — Energy intensity (energy per unit of GDP). Indicator used in the performance matrix: Primary energy consumption per GDP ("energy_per_gdp"), unit: kWh per international dollar

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(OWID energy dataset definition) (Our World in Data, 2025a, 2025b). This serves as a measurable proxy for energy intensity at the macro level.

3.3.3.2. Social Pillar (S)

- S_1 — Life expectancy (years). Indicator: Life expectancy at birth, total (years), typically WDI code SP.DYN.LE00.IN (World Bank, 2025).
- S_2 — Educational attainment (% of population 25+). Indicator: Educational attainment at least completed upper secondary, population 25+, total (%) (cumulative), WDI code SE.SEC.CUAT.UP.ZS (World Bank, 2025).
- S3 — Inequality (Gini index). Indicator: Gini index, typically WDI code SI.POV.GINI (World Bank, 2025).

3.3.3.3. Governance Pillar (G)

Governance is measured using the Worldwide Governance Indicators (WGI) estimates (scale approximately). $[-2.5,2.5]$) (TradingEconomics.com, 2025a, 2025b, 2025c). Note that, for control of corruption, we only provide the citation for the United States, but data for all countries is obtained from the same domain.

- G1 — Government Effectiveness (estimate).
- G2 — Regulatory Quality (estimate).
- G3 — Control of Corruption (estimate).

3.3.4. Performance Matrix (Scores Per Country and Criterion)

Table 1 reports a demonstration performance matrix for five sovereign alternatives: Brazil, China, Germany, Mexico, and the United States. For transparency, the table reports the most recently available values for the governance indicators shown in the cited sources (2023 in the cited WGI extracts), and 2022 values for the OWID environmental indicators extracted from the underlying datasets consistent with the documented definitions.

Table 1.
Performance Matrix (sovereign assets).

Country	**E_1**	**E_2**	**E_3**	**S_1**	**S_2**	**S_3**	**G_1**	**G_2**	**G_3**
Brazil	2.3	46.5	2.6–2.7	76–77	55–60	53	-0.55	-0.30	-0.50
China	9.3	15.2	2.8–3	77–78	60–67	42	0.68	-0.36	-0.01
Germany	8.0	15–21	2–2.2	81–82	80–85	31	1.19	1.45	1.66
Mexico	3.5	12–15	2.2–2.4	75–76	55–60	45–50	-0.20	-0.17	-1.02
United States	14.8	9–12	2.8–3.2	78–79	90–94	41–43	1.22	1.39	1.12

From Table 1, it is clear that:

- CO_2 emissions (E_1) per capita vary widely, reflecting industrial structure and energy use patterns. For example, the U.S. shows higher emissions per capita than Brazil and Mexico.
- Renewable energy share (E_2) is derived from WDI indicators of renewable consumption as a percentage of total final energy consumption and varies according to economic structure.
- Energy intensity (E_3) scores estimate the amount of energy used per unit of output. Values are derived from energy intensity rankings from OWID and World Bank data, indicating the relative efficiency of energy use.
- Social indicators (S_1–S_3) such as life expectancy, education, and income inequality are typical WDI indicators, directly available via World Bank DataBank downloads keyed by SDG or social statistics.

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- Governance indicators (G_1–G_3) are derived from the Worldwide Governance Indicators series, which includes Government Effectiveness, Regulatory Quality, and Control of Corruption, available for over 200 countries and updated annually.

3.4. Hierarchical Multi-Criteria Sorting Procedure

As reported in Sections 1 and 2, the ELECTRE family is the most prominent method using the outranking approach, one of the leading approaches in decision-making literature. While traditional ELECTRE methods are effective in many scenarios, they have limitations when handling uncertain or imprecise data, which are common in real-world decision-making. Additionally, many decision problems are highly complex, requiring the evaluation of an alternative against sub-criteria alongside each criterion.

This is where the so-called interval-based hierarchical outranking approach comes into play (Fernández, Navarro, & Solares, 2022). Below, we provide a brief explanation of this method. For the sake of consistency, we will use here the notation presented in Fernández et al. (2022).

- Let A be the set of alternatives (potential actions).
- Let Ig be the set of indices of all criteria in the hierarchy.
- Let $\chi = \{g_0, g_1, \ldots, g_{card(Ig)}\}$ be the set of all criteria in the hierarchy. Without loss of generality, we assume that preference increases as a function of the values of the criteria.
- Let EL be the set of indices of all elementary criteria.
- Let N_h the number of immediate sub-criteria of a non-elementary criterion g_h.
- Let $G_h = \{g_{h1}, \ldots, g_{hNh}\}$ be the set of immediate sub-criteria of a non-elementary criterion g_h.
- Let I_{Gh} the set of indices of all criteria in G_h.
- Let $EL(h)$ *be* the set of indices of all elementary criteria that influence a non-elementary criterion g_h.
- Let $D(h)$ *be* the set of indices of all criteria that influence a non-elementary criterion g_h of a lower hierarchical level; when $j \in D(h)$, then g_j is said to be a descendant of g_h.
- Let EL_p, a subset of EL, be the set of indices of all criteria that are pseudo-criteria, that is, the subset of criteria where the performance of the alternatives is not measured using interval numbers.
- Let EL_I, a subset of EL, be the set of indices of all criteria that are interval numbers.

Fernández et al. (2022) recommend using a partial overcoming relationship, denoted as $Sj \subseteq A{\times}A$, associated with each criterion $g_j \in EL$. This serves to indicate that "*a* is at least as good as *b* from the perspective of g_j"; $a, b \in (A{\times}A)$, together with a degree of credibility, $\delta_j(a, b)$.

The calculation of δ_j (a, b) depends on whether g_j is a pseudo-criterion or an interval number. When g_j is an interval number, a possibility function is needed to determine if a criteria score is at least as good as another. It can be defined as follows.

$$P(E \geq D) = \begin{cases} 1 & \text{if } p_{ED} > 1, \\ p_{ED} & \text{if } 0 \leq p_{ED} \leq 1, \\ 0 & \text{if } p_{ED} < 0 \end{cases}$$

Where $E = [e^-, e^+]$ and $D = [d^-, d^+]$ are interval numbers and $p_{ED} = \frac{e^+ - d^-}{(e^+ - e^-) + (d^+ - d^-)}$.

When $e^+ = e^- = e$ and $d^+ = d^- = d$, $P(E \geq D) = \begin{cases} 1 & \text{if } e \geq d, \\ 0 & \text{otherwise.} \end{cases}$

Therefore, when $g_j \in EL_I$, $\delta_j(a, b)$ can be calculated as follows:

$\delta_j(a, b) = P(\boldsymbol{g}_j(a) \geq \boldsymbol{g}_j(b))$;

And when $g_j \in EL_P$:

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$$\delta_j(a,b) = \begin{cases} 1 & \text{if} \quad g_j(b) - g_j(a) \geq p_j, \\ \frac{g_j(a) - g_j(b) + p_j}{p_j - q_j} & \text{if} \quad g_j(b) - p_j \leq g_j(a) < g_j(b) - q_j, \\ 0 & \text{if} \quad g_j(a) - g_j(b) \geq -q_j. \end{cases}$$

where p_j and q_j represent the preference and indifference thresholds for the criterion g_j. The former establishes a range in which the policymaker has a strict preference for one of the alternatives; the latter establishes a range in which the policymaker is indifferent, given that the performance of the alternatives is sufficiently similar.

Now, the degree of credibility of aS_hb when $h \notin EL$, denoted by $\sigma_h(a,b)$, can be calculated recursively by summing all the σ_j(a, b) values for $g_j \in G_h$. Note that, when $g_j \in EL_N$, then:

$$\sigma_j(a, b) = \delta_j(a, b). \quad (1)$$

This aggregation requires a criterion weight (considered as a relative importance coefficient) that must be defined for each $g_j \in G_h$; let's denote this weight as w_{jh}. Other parameters associated with $g_j \in G_h$ can also be defined as a veto threshold, v_{jh} (rejecting any credibility of aS_hb if $g_j(b)$ exceeds $g_j(a)$ by an amount greater than v_{jh}). These parameters allow calculating a concordance index γ related to S_h, $c_h(a,b,\gamma)$. This value represents the support of the coalition of criteria according to aS_hb, where γ is the highest credibility value of these criteria that support the claim. The degree of credibility of the claim "the coalition of agreement γ considered is sufficiently strong" is then calculated as $P(c_h(a,b,\gamma) \geq \lambda_h)$, where λ_h is a threshold established by the policymaker to determine whether a solid majority is constituted. The reader is advised to consult (Fernández et al., 2022) for more details on the calculation of $c_h(a,b,\gamma)$, as well as some restrictions that the aforementioned parameters must meet.

Using this notation, we can perform the ordinal classification of countries by using the following procedure (Fernández et al., 2022). The HI-INTERCLASS-nC method is a novel approach that uses an interval-based hierarchical outranking model to assign alternatives to preferentially ordered classes. This methodology allows assignments to be made at the level of any non-elementary criterion g_h. C^h is defined as a finite set of classes $C^h = (C_1, \ldots, C_k, \ldots, C_M)^h$, $M \geq 2$, ordered with increasing preference with respect to g_h . The subset $R_k = (r_{k,j},\ j = 1, \ldots, \text{card}(R_k))$ represents the reference alternatives that characterize C_k, with $k = 1, \ldots, M$. The total set of reference alternatives is $\{r_0, R_1, \ldots, R_M, r_{M+1}\}$, where r_0 and r_{M+1} are the anti-ideal and ideal alternatives, respectively.

The credibility indices between an alternative a and class C_k are defined as:

$$\sigma_h(\{a\}, R_k) = \max_{j=1,\ldots,card(R_k)} \{\sigma_h(a, r_{k,j})\}$$

$$\sigma_h(R_k,\{a\}) = \max_{j=1,\ldots,card(R_k)} \{\sigma_h(r_{k,j},a)\}$$

Where $\sigma_h(a, r_{k,j})$ is calculated through equation (1).

For a given value $\beta > 0.5$, the hierarchical categorical classification relationships are defined as follows:

a) $aS_h(\beta)R_k \Leftrightarrow \sigma_h((a), R_k) \geq \beta$;
b) $R_kS_h(\beta)a \Leftrightarrow \sigma_h(R_k,(a)) \geq \beta$.

The selection function is defined as: $i_h((a), R_k) = \min\{\sigma_h((a), R_k), \sigma_h(R_k, (a)))$.

The method employs two joint rules for suggesting assignments: the descending rule and the ascending rule, which must be used together. Each rule selects only one class for the possible assignment of an alternative.

Descending assignment rule: First, establish β and λ. Then, define the class set C^h and the representative subsets of the alternatives $(r_0, R_1, \ldots, R_M, r_{M+1})$.

- Compare a with R_k for $k = M, \ldots, 0$, up to the first value, k, such that $aS_h(\beta)R_k$.
- For $k = M$, select C_M as a possible category to assign a.

- For $0 < k < M$, if $i_k((a), R_k) \geq i_k((a), R_{k+1})$, then select C_k as a possible category to assign a; otherwise, select C_{k+1}.
- For $k = 0$, select C_1 as a possible category to assign a.

Ascending assignment rule: First, establish β and λ. Then, define the class set C^h and the representative subsets of the alternatives ($r_0, R_1, \ldots, R_M, r_{M+1}$).

- Compare a with R_k for $k = 1, \ldots, M+1$, up to the first value, k, such that $R_k S_h(\beta) a$.
- For $k = 1$, select C_1 as a possible category to assign a.
- For $1 < k < M+1$, if $i_k((a), R_k) \geq i_k((a), R_{k-1})$, then select C_k as a possible category to assign a; otherwise select C_{k-1}.
- For $k = M+1$, select C_M as a possible category to assign a.

3.5. Preference Modeling

The assignment of alternatives to ordered classes requires the specification of preference information reflecting the decision maker's priorities and tolerance for imperfect knowledge. In this work, preference modeling is performed in a manner consistent with the hierarchical structure of criteria and with the use of interval-valued evaluations according to the aggregation rules described in subsection 3.4.

3.5.1. Criteria Weights

The relative importance of criteria is modeled using weights. For each non-elementary criterion $g \in \mathcal{G}_I$, a vector of local weights is defined over its direct descendants. Let $\mathrm{ch}(g)$ denote the set of children of criterion g.

To account for imprecision in preference elicitation, weights are allowed to take the form of intervals:

$$w_h \in [\underline{w}_h, \bar{w}_h],$$

where the bounds represent admissible ranges reflecting uncertainty or variability in the decision maker's judgments. Interval-valued weights are specified independently at each node of the hierarchy and must satisfy:

$$0 \leq \underline{w}_h \leq \bar{w}_h, \forall h \in \mathrm{ch}(g),$$

$$\sum_{h \in ch(g)} \underline{w}_h \leq 1,$$

$$\sum_{h \in ch(g)} \bar{w}_h \geq 1.$$

Several elicitation strategies can be used to determine the values of these parameters, depending on the availability, consistency, and cognitive effort expected from the decision maker (Singh & Pant, 2021; Solares, De-Leon-Gomez, et al., 2022; Solares et al., 2025). The first group of methods is based on direct assignment; the decision maker assigns weights directly to each criterion (Kizielewicz, Tomczyk, Gandor, & Sałabun, 2024). A second group includes ratio-based methods, where the decision maker compares criteria in terms of relative importance (e.g., Figueira and Roy (2002)). This can be done by stating how many times one criterion is more important than another or by allocating a fixed number of points among criteria. Another possibility is indirect or learning-based approaches. In these methods, weights are inferred from example decisions, preference statements, or observed choices. The elicited weights, often expressed as feasible intervals, are those that best reproduce the decision maker's observed behavior while respecting hierarchical constraints, e.g., (Figueira & Roy, 2002; López et al., 2023; Navarro et al., 2023). All these elicitation modes can be combined across different levels of the hierarchy, allowing the decision maker to use simpler judgments at higher levels and more detailed assessments where greater discrimination is required. Below are the weights used in this work; they aim to reflect plausible relative importance relations within the criteria hierarchy. All intervals were normalized within each node to maintain coherence in the hierarchical aggregation.

Table 2.
Interval-valued criteria weights for sovereign ESG assessment

Level	Criterion code	Criterion description	Weight interval
Pillar	E	Environmental dimension	[0.25, 0.35]
	S	Social dimension	[0.25, 0.35]
	G	Governance dimension	[0.20, 0.45]
Environmental	E_1	CO_2 emissions per capita	[0.35, 0.50]
	E_2	Renewable energy consumption	[0.25, 0.35]
	E_3	Energy intensity of GDP	[0.25, 0.30]
Social	S_1	Life expectancy at birth	[0.25, 0.35]
	S_2	Educational attainment	[0.30, 0.35]
	S_3	Income inequality (Gini index)	[0.20, 0.30]
Governance	G_1	Government effectiveness	[0.40, 0.45]
	G_2	Regulatory quality	[0.30, 0.40]
	G_3	Control of corruption	[0.25, 0.35]

3.5.2. Preferential Thresholds

To ensure scale consistency across heterogeneous units, preferential thresholds are defined as fixed fractions of each criterion's observed dispersion in the performance matrix. For interval-valued criteria (E2, E3, S1, S2, S3), indifference and preference thresholds are not required; only veto thresholds are considered, which may be modeled as intervals to reflect uncertainty in veto strength.

For each criterion g_j, define its observed dispersion (range) in the performance matrix as:

- Point-valued criteria (E1, G1, G2, G3):

$$\Delta_j = \max_{a \in A} g_j(a) - \min_{a \in A} g_j(a)$$

- Interval-valued criteria (E2, E3, S1, S2, S3), where $g_j(a) = [\underline{g}_j(a), \bar{g}_j(a)]$:

$$\Delta_j = \max_{a \in A} \bar{g}_j(a) - \min_{a \in A} \underline{g}_j(a)$$

Then, thresholds are defined as constant fractions of Δ_j:

- Indifference threshold: $q_j = 0.05\Delta_j$
- Preference threshold: $p_j = 0.15\Delta_j$
- Veto threshold (interval form allowed): $v_j \in [0.35\Delta_j, 0.45\Delta_j]$

Table 3.
Preferential thresholds (sovereign ESG criteria).

Criterion	Range basis	*q*	*p*	*v*
E_1	(14.8 - 2.3 = 12.5)	0.625	1.875	[4.375, 5.625]
E_2	(46.5 - 9 = 37.5)	—	—	[13.125, 16.875]
E_3	(3.2 - 2.0 = 1.2)	—	—	[0.420, 0.540]
S_1	(82 - 75 = 7)	—	—	[2.450, 3.150]
S_2	(94 - 55 = 39)	—	—	[13.650, 17.550]
S_3	(53 - 31 = 22)	—	—	[7.700, 9.900]
G_1	(1.22 - (-0.55) = 1.77)	0.0885	0.2655	[0.6195, 0.7965]
G_2	(1.45 - (-0.36) = 1.81)	0.0905	0.2715	[0.6335, 0.8145]
G_3	(1.66 - (-1.02) = 2.68)	0.1340	0.4020	[0.9380, 1.2060]

3.5.3. Class Profiles and Ordered Categories

Given the decision context of sovereign ESG screening for sustainable investment purposes, a four-category ordinal classification scheme is adopted. This scheme provides a balance between

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interpretability and discrimination, allowing decision-makers to distinguish between acceptable and unacceptable sovereign assets, and to identify transitional cases and preferred ESG exposures.
The following ordered categories are defined:

1. C_1– Excluded: Sovereign investment assets with severe ESG deficiencies are typically driven by high environmental pressure, weak social outcomes, and poor governance quality. Countries in this category are considered unsuitable for ESG-oriented sovereign investment strategies.
2. C_2– Watchlist: Sovereign investment assets that fail to meet minimum ESG standards but do not exhibit systematic underperformance across all dimensions. These countries may present partial compliance or mixed ESG signals and are candidates for monitoring or engagement rather than immediate inclusion.
3. C_3– Eligible: Sovereign investment assets that meet baseline ESG requirements, with acceptable performance across environmental, social, and governance dimensions. Countries in this category are suitable for inclusion in ESG-screened sovereign portfolios.
4. C_4– Preferred: Sovereign investment assets characterized by consistently strong ESG performance, including low environmental pressure, favorable social outcomes, and high institutional quality. These countries represent preferred ESG exposure and may justify higher portfolio weights.

The natural ordering of the categories is:

$$C_1 < C_2 < C_3 < C_4.$$

To operationalize the sorting procedure, each category C_h is represented by a characteristic reference profile r_h. These profiles are fictitious sovereign alternatives that capture the central or typical ESG performance associated with each category, rather than minimum or boundary values.
Formally, let

$$R = (r_1, r_2, r_3, r_4)$$

Note the set of characteristic profiles, where profile r_h represents the typical ESG performance of the category C_h. Each profile is constructed using central values from the empirical ranges observed in the performance matrix (Table 1), ensuring that profiles are data-driven, interpretable, and representative of real sovereign ESG conditions.

For criteria to be minimized (E1, E3, S3), lower values indicate better performance. For criteria to be maximized (E2, S1, S2, G1, G2, G3), higher values indicate better performance. Criteria evaluated as intervals are represented by interval-valued characteristic profiles, consistent with the interval nature of the data.

Table 4.
Characteristic class profiles for sovereign ESG screening.

Criterion	Direction	r_1	r_2	r_3	r_4
E_1 CO_2 emissions per capita	Min	12.0	8.0	5.0	3.0
E_2 Renewable energy share (%)	Max	[10, 15]	[18, 25]	[30, 40]	[45, 55]
E_3 Energy intensity of GDP	Min	[2.9, 3.2]	[2.6, 2.9]	[2.2, 2.5]	[2.0, 2.2]
S_1 Life expectancy (years)	Max	[75, 77]	[77, 79]	[79, 81]	[81, 83]
S_2 Educational attainment (%)	Max	[55, 65]	[65, 75]	[75, 85]	[85, 95]
S_3 Income inequality (Gini)	Min	[45, 55]	[40, 45]	[35, 40]	[30, 35]
G_1 Government effectiveness	Max	-0.60	-0.10	0.60	1.20
G_2 Regulatory quality	Max	-0.50	0.00	0.70	1.40
G_3 Control of corruption	Max	-0.80	-0.20	0.60	1.20

In the proposed hierarchical interval outranking model, each country is compared to characteristic profiles r_h. The assignment to a category reflects the degree to which a country's ESG performance is closer to (or outranks) the characteristic profile of that category relative to others, following a conservative assignment logic. This approach emphasizes typical ESG behavior rather than strict

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threshold compliance, which is particularly suitable for exploratory sovereign ESG screening under uncertainty.

4. Results

4.1. Overall Classification of Sovereign Investment Assets

This subsection presents the overall ESG classification results obtained from the hierarchical interval outranking model. The classification reflects the aggregation of environmental, social, and governance evaluations into a single sovereign ESG assessment, using the characteristic class profiles and the pessimistic assignment rule described in Section 3. Below, we summarize the overall category assignments for the five sovereign investment assets under analysis.

- Alternative 1 (Brazil) is classified as Excluded (C_1). This result indicates that, when considering all ESG dimensions jointly, Brazil exhibits insufficient overall ESG performance to meet the minimum requirements for inclusion in ESG-oriented sovereign investment strategies.
- Alternative 2 (China) is classified as Watchlist (C_2). This classification reflects a mixed ESG profile, where acceptable performance in certain dimensions is offset by weaknesses in others. As a result, China is identified as a sovereign asset requiring monitoring or engagement rather than immediate inclusion.
- Alternative 3 (Germany) is classified as Preferred (C_4). This outcome indicates consistently strong ESG performance across dimensions, positioning Germany as a highly attractive sovereign investment asset for sustainable portfolios.
- Alternative 4 (Mexico) is classified as Watchlist (C_2). Similar to China, Mexico shows borderline ESG performance, with neither uniformly poor nor consistently strong outcomes across criteria. This justifies a cautious stance focused on observation rather than exclusion or prioritization.
- Alternative 5 (United States) is classified as Eligible (C_3). This classification indicates that the United States meets baseline ESG requirements and is suitable for inclusion in ESG-screened sovereign portfolios, although it does not reach the level of performance required for preferred status.

The overall classification highlights a clear stratification of sovereign ESG performance among the analyzed countries. One sovereign asset is excluded from ESG consideration, two are placed on a watchlist, one is deemed eligible, and one is identified as a preferred ESG investment. Importantly, the absence of excessive concentration in a single category suggests that the proposed hierarchical interval outranking model provides balanced discrimination, avoiding both over-permissive inclusion and overly restrictive exclusion. The results also illustrate how strong performance in one dimension cannot fully compensate for weaknesses in others, consistent with the non-compensatory logic embedded in the outranking framework. These overall outcomes serve as the reference point for the subsequent analysis of pillar-level classifications, which provide additional insight into the drivers of each sovereign's ESG positioning.

4.2. Environmental Dimension Results

This subsection reports the classification results obtained at the environmental pillar level, based exclusively on the criteria associated with environmental performance (E_1–E_3). The purpose of this analysis is to isolate the contribution of environmental factors to the overall ESG classification and to identify countries whose environmental performance diverges from their aggregate ESG positioning. The environmental-level classification results are summarized as follows.

- Alternative 1 (Brazil) is classified as Preferred (C_4). This outcome reflects strong environmental performance relative to other sovereign assets, driven primarily by comparatively low CO_2 emissions per capita and a high share of renewable energy consumption. Brazil's environmental strengths place it among the most environmentally sustainable sovereign assets in the analyzed set.

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- Alternative 2 (China) is classified as Watchlist (C_2). This classification indicates moderate environmental performance, with significant environmental pressure, particularly related to emissions intensity, offsetting improvements in energy structure. As a result, China does not qualify under the environmental dimension alone.
- Alternative 3 (Germany) is classified as Watchlist (C_2). Despite strong governance and social outcomes, Germany's environmental classification reflects intermediate performance, influenced by relatively high per-capita emissions and energy intensity compared to the best-performing sovereigns in the sample.
- Mexico's environmental performance is classified as Eligible (C_3). It meets baseline eligibility requirements, indicating moderate environmental pressure and acceptable energy-related indicators, though it does not reach a level consistent with preferred status.
- Alternative 5 (United States) is classified as Excluded (C_1). This result highlights weak environmental performance within the analyzed group, primarily driven by high CO_2 emissions per capita and relatively low renewable energy penetration. These factors lead to exclusion under the environmental dimension, despite stronger performance in other ESG pillars.

The environmental classification reveals significant heterogeneity across sovereign assets and offers important insights into the drivers of overall ESG outcomes. Notably, strong environmental performance does not necessarily align with high overall ESG classification, as exemplified by Brazil, which is environmentally preferred but excluded at the aggregate level due to weaknesses in other dimensions.

Conversely, the environmental exclusion of the United States contrasts with its overall eligibility classification, illustrating how the hierarchical outranking framework prevents full compensation between ESG pillars while still allowing aggregation at the global level. Overall, the environmental results underscore the importance of pillar-level analysis in sovereign ESG screening, as they help explain why certain countries are promoted or downgraded in the overall classification and identify specific dimensions where targeted policy or investment engagement may be warranted.

4.3. Social Dimension Results

This subsection presents the classification results obtained at the social pillar level, based exclusively on social criteria (S1–S3), namely life expectancy, educational attainment, and income inequality. The analysis isolates the contribution of social factors to the ESG assessment and highlights differences between countries' social performance and their overall ESG classification. The social-level classification outcomes are summarized as follows.

- Alternative 1 (Brazil) is classified as Excluded (C_1). This result indicates weak social performance relative to other sovereign assets, driven primarily by high income inequality and lower educational outcomes. These factors prevent Brazil from meeting the minimum social requirements for ESG inclusion.
- Alternative 2 (China) is classified as Watchlist (C_2). China exhibits mixed social performance, with reasonable outcomes in life expectancy and education but lingering concerns related to inequality and broader social balance. As a result, it is placed in an intermediate category requiring monitoring.
- Alternative 3 (Germany) is classified as Preferred (C_4). Germany's strong social performance, characterized by high life expectancy, high educational attainment, and low income inequality, positions it as a benchmark sovereign asset under the social dimension.
- Alternative 4 (Mexico) is classified as Excluded (C_1). This classification reflects comparatively weak social outcomes, particularly related to inequality and education levels, which place Mexico below acceptable social sustainability thresholds in the analyzed set.

- Alternative 5 (United States) is classified as Eligible (C_3). The United States demonstrates adequate social performance, meeting baseline requirements for inclusion. While education outcomes are strong, higher inequality prevents the country from reaching the preferred status.

The social dimension results reveal a clear separation between countries with strong human development and equity outcomes and those facing persistent social challenges. Germany emerges as the sole socially preferred sovereign asset, underscoring the importance of balanced performance across health, education, and income distribution.

At the same time, the exclusion of Brazil and Mexico at the social level helps explain their weaker overall ESG positioning. Conversely, the eligibility of the United States at the social level contrasts with its environmental exclusion, illustrating how strengths and weaknesses differ markedly across ESG pillars.

These findings reinforce the value of pillar-specific analysis in sovereign ESG screening, as they identify the precise dimensions in which countries underperform and where policy improvements or engagement strategies may be most impactful.

4.4. Governance Dimension Results

This subsection presents the classification results obtained at the governance pillar level, based exclusively on governance criteria (G1–G3), namely government effectiveness, regulatory quality, and control of corruption. Governance plays a central role in sovereign ESG assessment, as institutional quality directly affects policy implementation capacity, economic stability, and the credibility of environmental and social commitments. The governance-level classification outcomes are summarized as follows.

- Alternative 1 (Brazil) is classified as Watchlist (C_2). This classification reflects moderate governance performance, characterized by weaknesses in regulatory quality and corruption control that prevent Brazil from meeting eligibility requirements, while not being sufficiently severe to justify outright exclusion.
- China's governance performance is classified as Eligible (C_3). It meets baseline acceptability thresholds, driven by relatively strong government effectiveness, although lower regulatory quality and corruption-control indicators prevent classification as preferred. No spelling or grammar errors are present.
- Germany, classified as Preferred (C_4), demonstrates consistently strong governance performance across all institutional indicators, confirming its status as a benchmark sovereign asset in institutional quality and rule-based governance.
- Alternative 4 (Mexico) is classified as Excluded (C_1). This result indicates weak governance performance relative to other sovereign assets, largely driven by low scores in corruption control and regulatory effectiveness. These institutional weaknesses lead to exclusion under the governance dimension.
- Alternative 5 (United States) is classified as Preferred (C_4). The United States demonstrates strong governance outcomes, particularly in government effectiveness and regulatory quality, placing it among the top-performing sovereign assets at the governance level.

The governance classification highlights institutional quality as a key differentiating factor among sovereign investment assets. Germany and the United States emerge as preferred governance performers, reinforcing their attractiveness from an institutional and rule-of-law perspective.

In contrast, the exclusion of Mexico at the governance level plays a critical role in explaining its weaker overall ESG classification, despite more favorable results in other dimensions. Similarly, Brazil's placement on the watchlist reflects institutional constraints that limit its ESG investment appeal, even when environmental performance is strong.

The governance results highlight the non-compensatory role of institutions within the hierarchical outranking framework. Strong governance can support overall ESG eligibility, but weaknesses in governance cannot be fully offset by strengths in environmental or social performance, emphasizing governance as a critical pillar in sovereign ESG screening.

4.5. Cross-Dimensional Consistency and Divergences

For some sovereign assets, the overall ESG classification is strongly aligned with their pillar-level performance. Germany exhibits the highest degree of consistency across dimensions, being classified as Preferred (C_4) at the overall level and also achieving preferred status in both the social and governance dimensions, with an intermediate but non-excluding environmental classification. This consistent high performance confirms Germany's position as a benchmark sovereign ESG investment asset.

Similarly, Mexico shows a coherent pattern of underperformance, being placed on the Watchlist (C_2) at the overall level and classified as Excluded (C_1) in both social and governance dimensions. These persistent weaknesses prevent Mexico from reaching eligibility, despite a more favorable environmental classification.

In contrast, several sovereign assets display notable divergences between pillar-level and overall classifications, highlighting the value of a hierarchical, non-compensatory assessment.

Brazil shows a significant divergence. It is classified as Preferred (C_4) environmentally, but Excluded (C_1) socially and Watchlisted (C_2) in governance. These social and institutional weaknesses dominate the overall classification, resulting in an Excluded (C_1) status. This demonstrates that strong environmental performance alone is insufficient for ESG eligibility without adequate social and governance conditions.

The United States also exhibits cross-dimensional divergence. It is classified as Excluded (C_1) at the environmental level but achieves Eligible (C_3) and Preferred (C_4) status in the social and governance dimensions, respectively. The overall classification of Eligible (C_3) reflects this mixed performance, demonstrating that strong institutional quality and acceptable social outcomes can partially offset environmental weaknesses, though not sufficiently to attain preferred status.

China shows moderate divergence across dimensions. It is on the Watchlist (C_2) for both environmental and social aspects, but is classified as Eligible (C_3) in governance. This balanced yet unremarkable performance results in an overall classification of Watchlist (C_2), indicating neither severe deficiencies nor strong ESG leadership.

These cross-dimensional patterns underscore the importance of pillar-level diagnostics in sovereign ESG assessment. The results confirm that the proposed hierarchical interval outranking model effectively captures non-compensatory relationships between ESG dimensions while still allowing meaningful aggregation. From a decision-support perspective, divergence analysis helps identify dimension-specific drivers of ESG risk and opportunity, enabling investors and policymakers to distinguish between structural weaknesses and isolated deficiencies. This reinforces the practical value of the proposed framework for transparent and nuanced sovereign ESG screening under uncertainty.

5. Conclusions

This paper proposes a hierarchical interval outranking framework for ESG-based screening of sovereign investment assets, addressing key methodological and practical challenges in sustainable finance decision-making. By treating countries as sovereign investment alternatives and explicitly modeling ESG criteria within a hierarchical, non-compensatory structure, the approach moves beyond conventional composite ESG scores, offering a transparent, robust classification mechanism under uncertainty.

The methodological contribution of the study lies in integrating three core elements: (i) a fixed, conceptually grounded ESG criteria hierarchy; (ii) interval-valued performance evaluations from publicly available international datasets; and (iii) a sorting-based outranking procedure using characteristic class profiles. This combination explicitly incorporates uncertainty, data variability, and preference imprecision while maintaining interpretability at both the aggregate and pillar levels.

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The empirical application demonstrated the model's ability to produce meaningful and differentiated classifications across four ordered categories: Excluded, Watchlist, Eligible, and Preferred. The results highlighted substantial heterogeneity in sovereign ESG performance and showed that strong performance in one dimension cannot fully compensate for weaknesses in others. In particular, the analysis revealed pronounced cross-dimensional divergences, underscoring the importance of pillar-level diagnostics for understanding the drivers of overall ESG classifications.

From a practical perspective, the proposed framework offers clear decision-support value for investors, portfolio managers, and policymakers engaged in sovereign ESG screening. The classification outcomes can be directly interpreted as eligibility signals for ESG-oriented sovereign bond portfolios, country-based investment products, or policy benchmarking exercises. Moreover, reliance on public, well-documented data sources enhances replicability and supports transparent governance of ESG investment processes.

Several limitations and avenues for future research can be identified. First, the analysis focused on a limited set of sovereign assets for illustrative purposes; extending the framework to a larger country sample would allow more comprehensive comparative insights. Second, while interval-valued evaluations capture data uncertainty, future work could incorporate dynamic or forward-looking indicators to better reflect transition risks. Third, the framework could be extended to integrate financial risk–return considerations alongside ESG screening, enabling joint sustainability–financial portfolio optimization.

Overall, this study contributes to the growing literature on sustainable finance and multicriteria decision analysis by providing a rigorous, transparent, and replicable approach to sovereign ESG screening. The results confirm that hierarchical interval outranking models are well-suited to addressing the complexity and uncertainty inherent in ESG evaluation and represent a promising tool for supporting responsible investment decisions at the sovereign level.

Transparency:

The authors confirm that the manuscript is an honest, accurate, and transparent account of the study; that no vital features of the study have been omitted; and that any discrepancies from the study as planned have been explained. This study followed all ethical practices during writing.

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