UNIMORE
UNIVERSITÀ DEGLI STUDI DI MODENA E REGGIO EMILIA

Dipartimento di Economia Marco Biagi

DEMB Working Paper Series

N. 255

# Multicriteria Decision Analysis (MCDA) for Sustainability Assessment in EU Countries

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May 2025

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ISSN: 2281-440X online

# Multicriteria Decision Analysis (MCDA) for Sustainability Assessment in EU Countries

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## *Abstract*

*This paper evaluates the environmental, social, and governance (ESG) performance of the 27 member states of the European Union (EU) to look at the urgent issue of sustainability within the EU. ESG criteria have emerged as critical metrics for measuring the sustainability and ethical impact of both corporate entities and nations. Considering the growing significance of these assessments in influencing responsible investment and policy decisions, this research ranks and evaluates the sustainability performance of EU member states using six multi-criteria decision-making (MCDM) techniques: TOPSIS, PROMETHEE II, VIKOR, SIR, ELECTRE, MURAME. Using data from the World Bank for the year 2021, 23 ESG criteria were selected, which included environmental protection, social rights, and governance quality. The selected criteria were carefully normalised using three different normalisation techniques: Vector Normalisation, Maximum Row Normalisation, and Maximum Column Normalisation. In order to guarantee consistency and robustness within the rankings generated by the six MCDM approaches, each normalisation technique was used. The findings underscore the importance of method selection and normalisation in ESG assessments, as different MCDM methods and normalisation techniques can lead to different outcomes. However, the study also demonstrates the value of using multiple methods in tandem to capture the multi-dimensional nature of sustainability.*

*Keywords: MCDM, ESG, EU countries, rankings, normalisation*

*JEL classification: C44; C54; D80.*

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# 1. Introduction

Climate change is the result of the conflict between natural systems and human activities that, based on a misconception of progress and development, affect these systems in harmful ways. Today, it is crucial to understand the causes of climate change and to become aware of the consequences on our lives, so that we can take profound action on our habits [1]. The first definition of sustainability is only found in the 1980s, thanks to the report 'Our Common Future' published by the World Commission on Environment and Development of the United Nations Environment Programme. The Commission, also known as the Brundtland Commission, introduced the concept of sustainable development, defined as 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. However, sustainability has become increasingly important at corporate and national level, thanks to the introduction of rules to reduce the impact of human activities, promoted first by the Kyoto Protocol and then by the Paris Agreement and the 2030 Agenda for Sustainable Development [2][3].

ESG (Environmental, Social, and Governance) rating is an assessment of the performance of an entity according to environmental, social and governance criteria. Entities can be companies, investments, countries, etc. Environmental area includes analysis of environmental impacts such as natural resource use, greenhouse gas emissions, waste management, energy efficiency and resource sustainability. [4] Social area assesses how a company manages relations with employees, suppliers, customers and local communities. It includes aspects such as human rights, labour practices, diversity and inclusion, health, education and safety. [4] Governance area analyses the quality of corporate governance, shareholders' rights, business ethics and transparency in business practices. [4] For countries, it may include government structure, political stability, and the level of corruption. [5]. These evaluations have become increasingly relevant for investors, as they provide a measure of an entity's sustainability and ethical impact and give more information than just economic performance.

One of the most involved agencies in ESG analysis is Morgan Stanley Capital International (MSCI), a company that researches and supplies global indices for the financial market [6]. Other institutes, such as the World Bank, generate indices that can be used to assess national sustainability and social responsibility. The main challenge in the ESG assessment of countries lies in the lack of standardisation; in fact, different rating agencies use a variety of sources and methodologies to evaluate ESG performance. These ratings can vary significantly between agencies due to differences in assessment criteria, data sources and analysis methods. Another challenge is the availability of data, as they are very often incomplete, leading to incorrect or inaccurate ratings [7].

This paper aims to assess the sustainability of EU countries by comparing different multi-criteria decision-making methods (MCDA): TOPSIS, PROMETHEE II, VIKOR, SIR, ELECTRE III and MURAME. In particular, the study seeks to apply these six methods to analyse the performance of the 27 EU member states according to environmental, social and governance (ESG) criteria, providing a comprehensive overview of their sustainability assessment. Using this set of ESG indicators, the work ranks countries on their performance in these areas and highlights the differences and similarities between the various assessment methods. The use of different MCDA methods allows for more robust and consistent results. For each method, the impact on the final

ranking of various types of normalisations was also considered. The work, therefore, aims to provide a solid basis for future research on improving these methods and developing sustainability strategies that can be adopted nationally and internationally. The choice to apply MCDA methods comes from their ability to handle complexity and multidimensionality, intrinsic characteristics of sustainability assessment, in ranking alternatives according to the criteria available to the Decision Maker.

## 2. Literature review

Due to increasing concerns about climate change and sustainability, companies have started to improve several aspects of their performance, including economic, social and governance (ESG) performance. In recent years, there have been several studies regarding ESG performance: research has focused on aspects such as the impact of climate change on ESG performance [8] or the relationship between corporate culture and ESG performance [9]. From a methodological point of view, multi-criteria analysis has proven to be a useful tool for evaluating the sustainability of companies. MCDA can be performed through various methods, of which the most widely used is the TOPSIS method (Technique for order preference by similarity to the ideal solution). TOPSIS is an MCDA method proposed by Hwang and Yoon in [10], it can be used for problems related to the selection and ranking of the best alternatives. Several research works have been carried out with the TOPSIS method, such as that of Su and Sun [11], who developed a technique with TOPSIS for applying ESG to mining companies. Nowadays, more methods have been developed, e.g. Zopounidis et al. [12] use multicriteria decision analysis (MCDA) with the PROMETHEE II method to formulate an alternative approach to ESG assessment. Meng and Shaikh [13] utilize the Fuzzy Analytic Hierarchy Process (AHP) and Weighted Aggregated Sum Product Assessment (WASPAS) methodology to evaluate investment strategies for the development of green finance. Netto et al. [14] apply the Analytic Hierarchy Process (AHP), Complex Proportional Appraisal (COPRAS), Full Consistency Method (FUCOM), Step Weighted Assessment Ratio Analysis (SWARA) and the Technique of Similarity of Order Preferences with the Ideal Solution (TOPSIS) to evaluate bonds. Quayson et al. [15] adopt the Ordinal Priority Approach (OPA) and Multi-Criteria Decision Making (MCDM) to develop a decision support tool for the natural resource extraction industry. Park and Jang [16] utilize the AHP method to evaluate investment decisions against several ESG factors in the country, to show how ESG elements are considered and how important they are to investors. Reig-Mullor et al. [17] realise a new hybrid methodology with AHP and TOPSIS techniques in a neutrosophic environment, implementing the model to leading oil and gas companies. Xidonas and Essner [18] develop a multi-objective based portfolio optimisation model, seeking to maximise ESG performance. Camargo et al. [19] compose a Robust ESG Index (ESGI) using a multi-criteria decision-making process (MCDM) with Robust Compromise (RoCo). Using this method, they improve the financial condition of healthcare by exploiting the CAMELS technique to compose a Financial Health Index (FHI). Despite the growing number of studies on the integration of ESG criteria into corporate valuations, there is limited specific focus on the application of these decision-making tools to European country contexts. Most of the current research focuses on specific sectors or geographic areas, such as extractive industries or emerging markets as demonstrated by Su and Sun [11] and Quayson et al. [15], leaving a significant gap regarding the comparative analysis of ESG performance at the country level in Europe.

Several studies have explored the application of Multi-Criteria Decision Analysis (MCDA) in ranking countries based on their Environmental, Social, and Governance (ESG) ratings, providing a structured framework for sustainability assessment and decision-making. By integrating multiple evaluation criteria, MCDA enables a more comprehensive and comparative analysis of national sustainability performance. Notably, Ziolo et al. [20], in their study published in *Sustainability*, employed the PROMETHEE method to rank 23 OECD countries based on seven groups of criteria designed to assess financial systems in alignment with the Equator Principles. Their findings highlight how MCDA methodologies can effectively support financial performance evaluation within a sustainability framework. More recently, Tan et al. [21], in an article published in *Mathematics*, utilised Principal Component Analysis (PCA) to examine country-level ESG performance. This approach provided a detailed understanding of strengths, weaknesses, and potential trade-offs among different ESG factors, offering valuable insights for policymakers in the development of national ESG strategies. Furthermore, López-García et al. [22], in their research published in the *Annals of Operations Research*, applied the TOPSIS method for country rankings based on sustainability criteria. When the relative weights of the criteria were known, standard TOPSIS was used; otherwise, the weights were estimated through UW-TOPSIS. The results revealed significant variations in weight distributions across countries, reflecting differing national priorities in sustainable development. However, a clear trend emerged: in all sectors analysed, ESG criteria consistently received higher estimated weights than financial criteria, underscoring the growing emphasis on sustainability in strategic decision-making at the national level.

A summary of the papers analysed in this study is provided in Table 1.

| Authors | Data | Methodology | Results |
|---|---|---|---|
| Su, J.; Sun, Y. | Five Chinese state-owned metal mining enterprises in 2020 regarding to 15 ESG criteria | CPT-TOPSIS model, a combination of TOPSIS model and the cumulative prospect theory (CPT). | CPT-TOPSIS more effectively captures non-rational factors in decision-making for state-owned mining enterprises compared to classic TOPSIS and PT-TOPSIS, which either ignore or only address psychological preferences at the primary indicator level. |
| Zopounidis, C.; Garefalakis, A.; Lemonakis, C.; Passas, I. | Data related to companies' environmental, social and governance (ESG) performance, collected from company reports and standardized ESG databases, during a transitional period for international accounting standards and narrative information standards as well | PROMETHEE II | The quality of financial statements has improved, especially in ESG-Environmental Information, with European companies showing greater improvements than those in the US. |

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|---|---|---|---|
| Meng, X.; Shaikh, G.M | 15 critical ESG criteria and sub-criteria | Fuzzy analytical hierarchy process (AHP) and fuzzy weighted aggregated sum product assessment (WASPAS). | Environmental factors are prioritized over governance and social factors in green finance, with green bonds, ESG integration, and renewable energy funds identified as the most important elements. |
| Lombardi Netto, Antonio, Valerio Antonio Pamplona Salomon, and Miguel Angel Ortiz Barrios. | 15 green bonds collected from https://epi.yale.edu and https://www.kiplinger.com. From green bonds literature and Kiplinger database, seven indicators were identified as criteria for MCDA application. | Analytic hierarchy process (AHP), complex proportional assessment (COPRAS), full consistency method (FUCOM), step-wise Weights Assessment Ratio Analysis (SWARA), and TOPSIS | A moderate positive correlation between some ranks, with all ranks coinciding at the top position, while divergence occurred due to differing ranking methodologies. |
| Quayson, M.; Bai, C.; Mahmoudi, A.; Hu, W.; Chen, W.; Omoruyi, O. | 3 main criteria and 25 sub-criteria identified through literature reviews and company sustainability reports. | Ordinal Priority Approach (OPA) | "E" is the most important factor, followed by "S" and "G," and integrating ESG into the natural resource industry can enhance the credibility of sustainability performance reporting in supply chain management. |
| Park, S.R.; Jang, J.Y. | ESG criteria from the five most reliable ESG information providers: Stakeholder Capitalism Metric (World Economic Forum 2020), SASB (2020), Refinitiv (2021), MSCI (2020), and S&P Global (2021). | AHP model | Institutional investors place more importance on environmental and governance factors compared to social factor. |
| Reig-Mullor, J.; Garcia-Bernabeu, A.; Pla-Santamaria, D.; Vercher-Ferrandiz, M. | ESG performance of leading oil and gas energy firms (turnover of more than 100 billion dollars in 2019) worldwide. The non-financial sustainability indicators were obtained | Hybrid methodology: AHP and TOPSIS under a neutrosophic environment. | The rankings of oil and gas energy firms obtained differ depending on the formulation representing the experts' judgments. |

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|---|---|---|---|
| | from the EIKON database: 3 categories of indicators based on the ESG sustainability framework and 10 sub-criteria. | | |
| Xidonas, P.; Essner, E. | Four indices have been selected: the EURO STOXX 50, the CAC 40, the DAX and the DJIA. The financial performance is assessed through a back testing. | Maximum ERP (Environmental Risk Performance), maximum SRP (Social Risk Performance), maximum GRP (Governance Risk Performance) and minimax (which minimizes overall risk by maximizing returns in all categories). | Portfolios optimized with the minimax-based ESG risk model outperformed benchmarks like EURO STOXX 50, CAC 40, DAX, and DJIA, delivering higher yields without significantly increasing volatility. |
| Camargo, H.G.; ANTUNES, J.; Wanke, P. | The original sample is Forbes Global 2000. With the data intersection from Yahoo Finance, Bloomberg's ESG and S&P Global ESG, we finished with 834 companies, from 43 countries and 35 economic sectors. The years observed are 2018 until 2021 | ESG Robust Index (ESGI) – through a MultiCriteria Decision-Making (MCDM) with Robust Compromise (RoCo). Composition of Financial Health Index (FHI). | The composite ESGI outperforms individual components, with some industries showing a positive correlation with ESG practices, though there are instances of no correlation or negative correlation. |
| Ziolo, Magdalena, et al. | 23 OECD countries based on financial system sustainability | PROMETHEE | 23 OECD countries were ranked according to seven groups of criteria defined for financial system assessment respect the Equator Principles. |
| Tan, Yong, et al. | It references the National Natural Science Foundation of China, the Natural Science Foundation of Guangxi Zhuang Autonomous Region, and Guangxi Minzu University as funding sources | Principal component analysis | PCA offers a detailed understanding of country performance based on different ESG factors, identifying strengths, weaknesses, and potential trade-offs. It aids decision-makers in formulating ESG |

| | | | |
|---|---|---|---|
| | | | policies at the country level. |
| López-García, A., V. Liern, and B. Pérez-Gladish. | ESG and financial data from Refinitiv as of August 2022. The dataset included 100 countries from the EMEA region (Europe, Middle East, and Africa). | When the relative weights of the criteria were known, standard TOPSIS was used; otherwise, the weights were estimated through UW-TOPSIS. | Weight results vary by country, reflecting differing priorities among sustainable aspects. Results show higher estimated weights for ESG over financial criteria in all sectors. |

Table1. Literature review

This paper aims to fill this gap by adopting a variety of multi-criteria analysis techniques (MCDA) to assess the sustainability of European countries, with a focus on progress towards the Sustainable Development Goals of the 2030 Agenda. This gap is significant because a detailed and methodical evaluation of ESG performance at the European level could provide vital information to businesses, investors, and politicians that could help them create more successful long-term sustainability and governance plans. In particular, our study provides a unique framework for understanding which European countries are most effectively advancing towards achieving these goals, thus contributing to a broader and more systematic understanding of ESG performance at the European level. Moreover, this paper, compared to previous articles, collects 6 multi-criteria decision methods for the same analysis. This may be a preferable option to emphasise the robustness of the results obtained: if several methods give the same results, the results of the analysis are strengthened. On the other hand, each method has its own strengths and weaknesses: the use of a single method could introduce bias into the evaluation due to limitations, whereas using six different methods reduces the risk of relying on a single approach, offering a more balanced and complete view. The simultaneous adoption of six MCDA methods is a methodological innovation in the field of multi-criteria valuation, particularly in the context of ESG performance and sustainability. This method demonstrates a commitment to improving analytical techniques and may provide new insights and improvements for future research.

## 3. Data and Methodology

The data obtained come from the World Bank database. All EU member countries and 71 ESG criteria were selected, using data from the year 2021. From these, all criteria with missing values or where it was not possible to define whether the criterion should be maximised or minimised were removed. For example, population density depends very much on the context and the specific conditions of the country and can have conflicting effects for the three macro-categories. ESG (environmental, social and governance) criteria are used to assess companies' performance in terms of sustainability, driving responsible investment. This type of analysis is also applied to countries, assessing issues often overlooked by traditional ratings, such as respect for human rights, climate and energy, corruption and the quality of institutions. By integrating this analysis with traditional government bond ratings, ESG ranking can become a valuable tool for assessing the risk of government bonds. This allows investors to make well-informed investment decisions, considering a broader set of factors that may influence the long-term stability and sustainability of investments. Furthermore, the adoption of ESG criteria helps to promote more responsible and transparent practices globally, incentivising governments and companies to improve their performance in these critical areas [27]. From 71 initial criteria, our study involved 23, of which:

- 5 relate to the Environment area, in particular focusing on nature protection;

- 7 are in the Social area and deal with human rights and quality of institutions

- 11 are part of the Governance area and deal with aspects such as corruption and government effectiveness.

In order to construct the rankings using multi-criteria methods, it is necessary to assign a set of parameters for each criterion. These parameters include the importance of the criterion, the identification of the type of criterion (benefit or cost), a preference function with associated thresholds for the application of PROMETHEE II and SIR, and thresholds for the application of ELECTRE III and MURAME. The criteria with the different parameters are shown in the Table 2.

| Criteria | Category | Type | Weight | Min Value | Max Value |
|---|---|---|---|---|---|
| Agricultural land (% of land area) | Environment | Max | 0,067 | 7,37 | 65,45 |
| Agriculture, forestry, and fishing, value added (% of GDP) | Environment | Max | 0,067 | 0,19 | 4,51 |
| Control of Corruption: Estimate | Governance | Max | 0,030 | -0,26 | 2,33 |
| Food production index (2014-2016 = 100) | Environment | Max | 0,067 | 75,6 | 128,07 |
| Forest area (% of land area) | Environment | Max | 0,067 | 1,44 | 73,73 |
| GDP growth (annual %) | Governance | Max | 0,030 | 2,84 | 15,12 |
| Gini index | Social | Min | 0,048 | 24,1 | 39 |
| Government Effectiveness: Estimate | Governance | Max | 0,030 | -0,17 | 1,96 |
| Government expenditure on education, total (% of government expenditure) | Social | Max | 0,048 | 7,11 | 14,25 |
| Individuals using the Internet (% of population) | Governance | Max | 0,030 | 74,86 | 98,86 |
| Labor force participation rate, total (% of total population ages 15-64) (modeled ILO estimate) | Social | Max | 0,048 | 64,68 | 82,79 |
| Mortality rate, under-5 (per 1,000 live births) | Social | Max | 0,048 | 2 | 6,4 |
| People using safely managed sanitation services (% of population) | Social | Max | 0,048 | 72,45 | 99,67 |
| Political Stability and Absence of Violence/Terrorism: Estimate | Governance | Max | 0,030 | 0,10 | 1,19 |
| Poverty headcount ratio at national poverty lines (% of population) | Social | Min | 0,048 | 10,2 | 22,9 |

| | | | | | |
|---|---|---|---|---|---|
| Proportion of seats held by women in national parliaments (%) | Governance | Max | 0,030 | 13,06 | 46,99 |
| Ratio of female to male labor force participation rate (%) (modeled ILO estimate) | Governance | Max | 0,030 | 66,37 | 89,65 |
| Regulatory Quality: Estimate | Governance | Max | 0,030 | 0,29 | 1,91 |
| Research and development expenditure (% of GDP) | Governance | Max | 0,030 | 0,47 | 3,43 |
| Rule of Law: Estimate | Governance | Max | 0,030 | -0,07 | 2,01 |
| Terrestrial and marine protected areas (% of total territorial area) | Environment | Max | 0,067 | 4,04 | 51,34 |
| Unemployment, total (% of total labor force) (modeled ILO estimate) | Social | Min | 0,048 | 2,8 | 14,78 |
| Voice and Accountability: Estimate | Governance | Max | 0,030 | 0,28 | 1,61 |

Table 2. Evaluation Criteria and descriptive statistics

Then, the data were normalised using Vector Normalisation, Maximum Row Normalisation and Maximum Column Normalisation [23]. Six different multi-criteria decision methods (MCDM) were used in this study: TOPSIS, VIKOR, PROMETHEE II, SIR-SAW, ELECTRE III, MURAME.

TOPSIS was developed by Huang and Yoon [10] and it is one of the most widely used due to its simplicity and ease of implementation. It is based on identifying an ideal solution, which maximises benefits and minimises costs, and an anti-ideal solution, which maximises costs and minimises benefits. The objective is to select the alternative with the smallest geometric distance from the ideal solution. The final preference order of the alternatives is obtained by ordering the Euclidean distances. VIKOR is based on the same assumptions as TOPSIS. Once the ranking with respect to the distance of the alternatives from the ideal and anti-ideal solution has been obtained, the alternatives are compared to see if there is a significant difference between them, in order to determine whether they can be defined as ‘trade-off solutions’ or whether one alternative is truly preferred over the other. PROMETHEE II is based on the pairwise comparison of alternatives in order to rank them according to a set of criteria. Brans et al. [24] reported six preference functions, which differ in their choice of indifference threshold q and preference threshold p. Two alternatives are indifferent for the j-th criterion as long as their distance does not exceed the indifference threshold q; one alternative is preferred over the other if the distance becomes greater than p. The final ranking is obtained by evaluating net flows, that are the difference between positive and negative flows. Positive flows indicate how much the reference alternative is preferred over the others, while negative flows indicate how much the other alternatives are preferred over the

reference alternative. The SIR method has the same theoretical foundation as PROMETHEE, ranking alternatives relative to net flows obtained by evaluating preference functions. [25] Two methodologies can be used to aggregate the data, SAW or TOPSIS. ELECTRE III is part of the ELECTRE family of methods. As opposed to ELECTRE I and II, this one introduces the indifference q, preference p and veto v thresholds. Based on the calculation of the concordance, discordance indices, a credibility matrix is developed as a test for the performance of each alternative. [26] This method is more complex but takes a more complete view of the alternatives and proceeds by eliminating the less favourable ones, so it is very useful when dealing with a problem with a large number of alternatives. MURAME is a hybrid method resulting from the combination of ELECTRE and PROMETHEE II. In the first step, it compares alternatives in pairs to construct outclass relations in exactly the same way as the ELECTRE methods; in the second step, once the credibility matrix has been calculated, positive and negative flows are calculated to order the alternatives according to net flows, as in the case of PROMETHEE II.

For the application of PROMETHEE II and SIR, we used the first preference function, denominated Usual Criterion: it is the simplest case, it does not use any type of parameter; the preference function is equal to 1 if the difference between the two actions is greater than 0, otherwise the choice between the two is indifferent. For ELECTRE III and MURAME, the indifference threshold q and preference threshold p values were calculated as a function of the standard deviation of each criterion, respectively 10% and 30%; the veto threshold value was calculated as the difference between the maximum and minimum value of the criterion performance.

## 4. Analysis of results

Figures 2 - 5 show the final rankings of the 27 EU countries relative to the 23 chosen ESG criteria. Within each method, the rankings obtained with the maximum row and column normalisation coincide perfectly, so that the two normalisation methods are equivalent. Specifically, ranking is unaffected by the type of normalisation selected in PROMETHEE II, VIKOR, SIR-SAW, ELECTRE III, and MURAME. In addition, in the PROMETHEE II, VIKOR, SIR-SAW and ELECTRE III methods, the ranking obtained with normalisations is practically the same as that obtained without normalisation, except for a few inversions, probably due to the proximity of some alternatives. In TOPSIS, however, the ranking obtained without normalisation coincides with those with maximum row and column normalisation. The choice of method is of fundamental importance in determining the final ranking: if we consider vector normalisation, for example, we see that Denmark (A7) occupies first position in PROMETHEE II, SIR-SAW, ELECTRE III, but is eleventh, fourth and second respectively in TOPSIS, VIKOR and MURAME; Slovenia (A25) is first in TOPSIS and VIKOR, sixth in PROMETHEE II and SIR-SAW, fourth and nineteenth in ELECTRE III and MURAME. The last positions are always occupied by countries such as Italy, Malta, Greece and Cyprus. With the maximum row/column normalisation, the situation is quite similar; in fact, the first positions are occupied by Luxembourg (A18), Denmark (A7) and Slovenia (A25), while the last ones are occupied by the same countries as above.

To verify the correlation between the employed Multi-Criteria Decision Methods, we applied Spearman's rank correlation coefficient. This non-parametric measure, denoted as $\rho$, assesses the strength and direction of the monotonic relationship between two variables. The coefficient ranges from -1 to 1, with interpretations as follows:

$\rho = -1$: Indicates a perfect negative correlation, where an increase in one variable corresponds to a proportional decrease in the other.

$\rho = 0$: Denotes no monotonic correlation, suggesting the absence of a consistent relationship between the variables.

$\rho = 1$: Represents a perfect positive correlation, where an increase in one variable corresponds to a proportional increase in the other.

Spearman's coefficient is particularly advantageous when dealing with data that do not adhere to a normal distribution or contain significant outliers, as it relies on the ranks of the data rather than their raw values. This characteristic renders it less sensitive to extreme values and suitable for ordinal or non-linear data [28]. In our analysis, the results revealed a moderate correlation among the different approaches. This finding implies that, despite potential variations in individual scores, the overall ranking of countries remains relatively consistent across various methods. For instance, Northern European countries consistently hold the top positions in each ranking, indicating a substantial agreement among the applied methodologies. The application of Spearman's rank correlation coefficient in this context is justified by the nature of the data and the objective of capturing monotonic rather than strictly linear relationships. This approach offers a more robust understanding of the correlations between the 6 methods applied, especially when addressing non-parametric data or distributions that deviate from normality.

| TOPSIS | PROMETHEE II | VIKOR | SIR-SAW | ELECTRE III | MURAME |
|---|---|---|---|---|---|
| Luxembourg | Denmark | Slovenia | Denmark | Denmark | Denmark |
| Slovenia | Netherlands | Czechia | Netherlands | Netherlands | Netherlands |
| Poland | Luxembourg | Poland | Luxembourg | Luxembourg | Luxembourg |
| Spain | Sweden | Denmark | Sweden | Finland | Sweden |
| Portugal | Finland | France | Finland | Slovenia | Finland |
| Austria | Slovenia | Austria | Slovenia | Sweden | Slovenia |
| France | Austria | Estonia | Austria | Czechia | Austria |
| Bulgaria | Estonia | Slovak Rep. | Estonia | Estonia | Ireland |
| Germany | Germany | Portugal | Germany | Austria | Czechia |
| Slovak Rep. | Czechia | Lithuania | Czechia | Ireland | Germany |
| Latvia | Ireland | Netherlands | Ireland | Poland | Estonia |
| Romania | Poland | Latvia | Poland | Portugal | Belgium |
| Estonia | Belgium | Hungary | Belgium | Germany | Poland |
| Denmark | Portugal | Spain | Portugal | Belgium | Portugal |
| Sweden | Spain | Germany | Spain | Spain | France |
| Finland | Lithuania | Croatia | Lithuania | Latvia | Lithuania |
| Czechia | Hungary | Luxembourg | Hungary | Lithuania | Latvia |
| Lithuania | France | Belgium | France | Slovak Rep. | Spain |
| Ireland | Latvia | Sweden | Latvia | France | Hungary |
| Netherlands | Slovak Rep. | Finland | Slovak Rep. | Hungary | Slovak Rep. |
| Hungary | Cyprus | Romania | Cyprus | Bulgaria | Croatia |
| Belgium | Bulgaria | Bulgaria | Bulgaria | Cyprus | Cyprus |
| Greece | Croatia | Ireland | Croatia | Romania | Romania |
| Italy | Romania | Italy | Romania | Croatia | Malta |
| Croatia | Malta | Cyprus | Malta | Italy | Bulgaria |
| Cyprus | Greece | Greece | Greece | Malta | Italy |
| Malta | Italy | Malta | Italy | Greece | Greece |

Figure 2. Ranking obtained with the different methods, without normalisation.

| TOPSIS | PROMETHEE II | VIKOR | SIR-SAW | ELECTRE III | MURAME |
|---|---|---|---|---|---|
| Slovenia | Denmark | Slovenia | Denmark | Denmark | Luxembourg |
| Luxembourg | Netherlands | Czechia | Netherlands | Netherlands | Denmark |
| Finland | Luxembourg | Poland | Luxembourg | Luxembourg | Sweden |
| Germany | Sweden | Denmark | Sweden | Finland, Slovenia | Spain |
| Latvia | Finland | France | Finland | Sweden | Netherlands |
| Estonia | Slovenia | Austria | Slovenia | Czechia | Austria |
| Austria | Austria | Estonia | Austria | Estonia | Estonia |
| Sweden | Estonia | Slovak Rep. | Estonia | Austria | Lithuania |
| France | Germany | Portugal | Germany | Ireland, Poland | Latvia |
| Poland | Czechia | Lithuania | Czechia | Portugal, Germany | Portugal |
| Denmark | Ireland | Netherlands | Ireland | Belgium | Finland |
| Lithuania | Poland | Latvia | Poland | Spain | France |
| Netherlands | Belgium | Hungary | Belgium | Latvia | Ireland |
| Czechia | Portugal | Spain | Portugal | Lithuania | Germany |
| Bulgaria | Spain | Germany | Lithuania | Slovak Rep. | Belgium |
| Hungary | Lithuania | Croatia | Spain | France | Bulgaria |
| Romania | Hungary | Luxembourg | France | Hungary | Romania |
| Portugal | France | Belgium | Latvia | Bulgaria | Poland |
| Slovak Rep. | Latvia | Sweden | Hungary | Cyprus | Slovenia |
| Croatia | Slovak Rep. | Finland | Slovak Rep. | Romania, Croatia | Greece |
| Spain | Cyprus | Romania | Cyprus | Italy, Malta | Croatia |
| Ireland | Bulgaria | Bulgaria | Bulgaria | Greece | Slovak Rep. |
| Belgium | Croatia | Ireland | Croatia | | Czechia |
| Greece | Romania | Italy | Romania | | Hungary |
| Italy | Malta | Cyprus | Malta | | Cyprus |
| Cyprus | Greece | Greece | Greece | | Malta |
| Malta | Italy | Malta | Italy | | Italy |

Figure 3. Ranking obtained by the various methods, with vector normalisation

| TOPSIS | PROMETHEE II | VIKOR | SIR-SAW | ELECTRE III | MURAME |
|---|---|---|---|---|---|
| Luxembourg | Denmark | Slovenia | Denmark | Denmark | Luxembourg |
| Slovenia | Netherlands | Czechia | Netherlands | Netherlands | Denmark |
| Poland | Luxembourg | Poland | Luxembourg | Luxembourg | Sweden |
| Spain | Sweden | Denmark | Sweden | Finland, Slovenia | Spain |
| Portugal | Finland | France | Finland | Sweden | Netherlands |
| Austria | Slovenia | Austria | Slovenia | Czechia | Austria |
| France | Austria | Estonia | Austria | Estonia | Estonia |
| Bulgaria | Estonia | Slovak Rep. | Estonia | Austria | Lithuania |
| Germany | Germany | Portugal | Germany | Ireland, Poland | Latvia |
| Slovak Rep. | Czechia | Lithuania | Czechia | Portugal, Germany | Portugal |
| Latvia | Ireland | Netherlands | Ireland | Belgium | Finland |
| Romania | Poland | Latvia | Poland | Spain | France |
| Estonia | Belgium | Hungary | Belgium | Latvia | Ireland |
| Denmark | Portugal | Spain | Portugal | Lithuania | Germany |
| Sweden | Spain | Germany | Lithuania | Slovak Rep. | Belgium |
| Finland | Lithuania | Croatia | Spain | France | Bulgaria |
| Czechia | Hungary | Luxembourg | France | Hungary | Romania |
| Lithuania | France | Belgium | Latvia | Bulgaria | Poland |
| Ireland | Latvia | Sweden | Hungary | Cyprus | Slovenia |
| Netherlands | Slovak Rep. | Finland | Slovak Rep. | Romania, Croatia | Greece |
| Hungary | Cyprus | Romania | Cyprus | Italy, Malta | Croatia |
| Belgium | Bulgaria | Bulgaria | Bulgaria | Greece | Slovak Rep. |
| Greece | Croatia | Ireland | Croatia | | Czechia |
| Italy | Romania | Italy | Romania | | Hungary |
| Croatia | Malta | Cyprus | Malta | | Cyprus |
| Cyprus | Greece | Greece | Greece | | Malta |
| Malta | Italy | Malta | Italy | | Italy |

Figure 4. Ranking obtained with the different methods, with maximum row normalisation

| TOPSIS | PROMETHEE II | VIKOR | SIR-SAW | ELECTRE III | MURAME |
|---|---|---|---|---|---|
| Luxembourg | Denmark | Slovenia | Denmark | Denmark | Luxembourg |
| Slovenia | Netherlands | Czechia | Netherlands | Netherlands | Denmark |
| Poland | Luxembourg | Poland | Luxembourg | Luxembourg | Sweden |
| Spain | Sweden | Denmark | Sweden | Finland, Slovenia | Spain |
| Portugal | Finland | France | Finland | Sweden | Netherlands |
| Austria | Slovenia | Austria | Slovenia | Czechia | Austria |
| France | Austria | Estonia | Austria | Estonia | Estonia |
| Bulgaria | Estonia | Slovak Rep. | Estonia | Austria | Lithuania |
| Germany | Germany | Portugal | Germany | Ireland, Poland | Latvia |
| Slovak Rep. | Czechia | Lithuania | Czechia | Portugal, Germany | Portugal |
| Latvia | Ireland | Netherlands | Ireland | Belgium | Finland |
| Romania | Poland | Latvia | Poland | Spain | France |
| Estonia | Belgium | Hungary | Belgium | Latvia | Ireland |
| Denmark | Portugal | Spain | Portugal | Lithuania | Germany |
| Sweden | Spain | Germany | Lithuania | Slovak Rep. | Belgium |
| Finland | Lithuania | Croatia | Spain | France | Bulgaria |
| Czechia | Hungary | Luxembourg | France | Hungary | Romania |
| Lithuania | France | Belgium | Latvia | Bulgaria | Poland |
| Ireland | Latvia | Sweden | Hungary | Cyprus | Slovenia |
| Netherlands | Slovak Rep. | Finland | Slovak Rep. | Romania, Croatia | Greece |
| Hungary | Cyprus | Romania | Cyprus | Italy, Malta | Croatia |
| Belgium | Bulgaria | Bulgaria | Bulgaria | Greece | Slovak Rep. |
| Greece | Croatia | Ireland | Croatia | | Czechia |
| Italy | Romania | Italy | Romania | | Hungary |
| Croatia | Malta | Cyprus | Malta | | Cyprus |
| Cyprus | Greece | Greece | Greece | | Malta |
| Malta | Italy | Malta | Italy | | Italy |

Figure 5. Ranking obtained with the different methods, with maximum column normalisation

| | TOPSIS | PROMETHEE II | VIKOR | SIR-SAW | ELECTRE III | MURAME |
|---|---|---|---|---|---|---|
| **TOPSIS** | 1 | 0,689 | 0,559 | 0,686 | 0,65 | 0,56 |
| **PROMETHEE II** | 0,689 | 1 | 0,5 | 0,998 | 0,677 | 0,7 |
| **VIKOR** | 0,559 | 0,5 | 1 | 0,499 | 0,578 | 0,487 |
| **SIR-SAW** | 0,686 | 0,998 | 0,499 | 1 | 0,681 | 0,697 |
| **ELECTRE III** | 0,65 | 0,677 | 0,578 | 0,681 | 1 | 0,881 |
| **MURAME** | 0,56 | 0,7 | 0,487 | 0,697 | 0,881 | 1 |

Figure 6. Spearman Indices for each couple of methods

Regardless of the method and standardisation used, Northern European countries always occupy the top positions in the different rankings, especially Denmark, Luxembourg, the Netherlands, Slovenia, Sweden, etc. Their governance, in fact, is known to be effective and transparent compared to other EU countries, in addition to their highly regarded welfare systems. On the contrary, the countries most often found at the bottom of the ranking are Italy, Greece, Malta, Cyprus: these countries are characterised by well-known financial problems, political instability and corruption. Despite having a remarkable cultural and natural patrimony, as far as the environment is concerned, they are susceptible to pollution and waste management problems; furthermore, these countries are critical in criteria such as political instability, control of corruption and government effectiveness. It is clear that the choice of normalisation is an important factor in determining the final ranking but does not have the same impact for all methods: PROMETHEE II, VIKOR, SIR-SAW and ELECTRE III return an almost identical ranking in all cases seen. The choice of method, however, is decisive. With the same normalisation, the rankings can be quite different from each other; however, it must be remembered that in the PROMETHEE II, SIR-SAW, ELECTRE III and MURAME methods, the ranking obtained is strongly influenced by the choice of preference function and/or threshold parameters.

## 5. Conclusion

In this study the 27 countries of the European Union were evaluated according to their environmental, social and governance performance, using 6 multi-criteria methods to assess the robustness of the results obtained. The TOPSIS method allows the development of a ranking of alternatives by taking into account the distances to the best and worst solutions; PROMETHEE II and SIR allow preferences to be taken into account by assigning a so-called preference function to the criteria; VIKOR is based on finding a compromise solution that is as close as possible to the ideal solution; ELECTRE III and MURAME compare alternatives by means of outperformance relations. All methods are considered excellent tools to support decision-making in the presence of multiple, often conflicting criteria. Each has unique characteristics that make it suitable for different situations, so it is difficult to determine which is the best. Criteria considered include protection of the ecosystem, quality of institutions, labour rights and political stability. The choice of method depends strongly on the specific context of the decision problem. Generally, TOPSIS, PROMETHEE II or SIR-SAW are chosen for problems with a small number of criteria and alternatives because they are simpler and easier to apply; VIKOR is useful when trade-offs between criteria are searched for; for complex problems with many criteria and alternatives, ELECTRE III or MURAME may be useful. Regardless of the method, the results indicate that Sweden, Finland, Luxembourg, among others, excel in ESG implementation at the national level. Countries, on the other hand, such as Italy, Malta, and Greece, have several critical issues, so they should focus on the analysed factors, especially governance aspects, and try to improve their performance. This study is crucial to help policy makers improve the effectiveness of interventions and allocation of resources, identifying which areas are most critical within the country and directing investors to the most sustainable countries. Countries that are ranked in the top positions have an increased global reputation and may attract more investment; conversely, countries ranked in the bottom positions may be motivated to improve their ESG performance to remain competitive in the European or global arena.

ESG rankings are also particularly useful for assessing the progress of countries towards the Sustainable Development Goals (SDGs) set by the United Nations. Policy makers can monitor progress and identify which areas need more attention. Although this paper can be interesting and contribute to ESG performance measurements at the national level, it has some limitations: the dataset considered takes the year 2021 as a reference, so it cannot be excluded that the current situation will be different. The choice of this year is due to the lack of complete data for all EU countries in following years. Furthermore, only 23 criteria were chosen, so a more complete analysis could provide a different ranking. Taking these limitations in consideration, future research could focus on analysing more recent periods, once data become available, and include more ESG criteria, to check how the results differ from those of the current study [29]. Furthermore, considering several factors, such as the number and nature of decision criteria, data availability, and the number of decision-makers, it would be useful to approach the problem with a hybrid approach, combining different methods of normalisation, weighting and ranking development, in order to have more reliable data [30].

**Funding**
This work was funded by European Union under the NextGeneration EU Programme within the Plan “PNRR - Missione 4 “Istruzione e Ricerca” - Componente C2 Investimento 1.1 “Fondo per il Programma Nazionale di Ricerca e Progetti di Rilevante Interesse Nazionale (PRIN)” by the Italian Ministry of University and Research (MUR), Project title: “Climate risk and uncertainty: environmental sustainability and asset pricing”. Project code "P20225MJW8" (CUP: E53D23016470001), MUR D.D. financing decree n. 1409 of 14/09/2022.

The work was supported also by the University of Modena and Reggio Emilia for the FAR2022 and FAR2023 projects.

**Conflict of interest**
The authors declare that they have no conflict of interest.

**Availability of data and materials**
Not applicable.

**Code availability**
Not applicable.

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## Figures

## Tables