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ESG criteria for the evaluation of European countries: a multicriteria analysis (MCDA)

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Silvia Muzzioli[a] and Lorenzo Vitale[b]

Abstract

In recent decades, climate change and sustainability have emerged as critical issues within global economic and political contexts. This paper investigates the application of ESG (Environmental, Social, and Governance) criteria for evaluating European countries using Multi-Criteria Decision Analysis (MCDA) methods. Following an overview of the evolution of climate policies and key sustainability frameworks, four MCDA methods (TOPSIS, VIKOR, PROMETHEE and SIR) are analyzed in detail. Each method is explored from both a theoretical perspective and through practical implementations in Python. Additionally, various normalisation techniques are applied to the selected methods to examine their influence on the results and to study the differences arising from their application (in detail: Vector Normalisation, Linear Normalisation, Row/Column Maximum Normalisation). A case study is presented to evaluate European countries based on ESG data, comparing the effectiveness and differences among the selected methods. The results highlight the potential of MCDA approaches, combined with normalisation techniques to support complex decision-making processes, providing an integrated and systematic perspective to address sustainability challenges.

Keywords*: ESG (Environmental, Social, Governance), MCDM (Multi-Criteria Decision Making), Normalisation.*

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1. Introduction

In recent decades, climate change has emerged as one of the most critical and urgent global challenges. The need to address the environmental, economic, and social consequences of global warming has driven governments, institutions, and businesses to revise their policies and strategies. In this context, the concept of sustainability has taken a central role, promoting an integrated approach that considers not only the environmental dimension but also the social and economic aspects. The evolution of climate policies, from the first Conference of the Parties (COP1) to the recent COP28, demonstrates a growing international commitment to combating climate change. At the same time, there has been an increasing need to evaluate and monitor organizations' environmental, social, and governance (ESG) performance, leading to the widespread adoption of ESG ratings. These tools provide a framework for measuring and comparing the impact of companies' activities in terms of sustainability, increasingly influencing the decisions of investors, consumers, and other stakeholders. In this context, the paper aims to explore multi-criteria decision-making (MCDM) methods, which are tools that allow for the evaluation and selection of complex alternatives in the presence of multiple conflicting criteria. Data normalization, which enables the comparison of variables of different natures, and the application of multi-criteria methods such as TOPSIS, VIKOR, PROMETHEE, and SIR, form the core of the study. Each method will be described in detail, highlighting its methodology, main steps, and implementation in Python. Finally, the paper will conclude with an applied case study, where the analyzed methods will be tested to demonstrate their effectiveness and usefulness in solving complex problems related to sustainability and ESG rating evaluation, highlighting the differences between them. The case in question involves the classification of 2412 European companies whose data were sourced from LSEG (London Stock Exchange Group), a global provider of financial markets infrastructure and data. The objective of this work is to provide a comprehensive and in-depth overview of multi-criteria methods and their use in the context of sustainability, offering both practical and theoretical insights for their application in increasingly relevant decision-making areas in the contemporary era.

2. Literature Review

Climate change, in recent times, has caused growing concern globally, prompting companies in particular to improve various aspects of their performance related to the concept of sustainability by focusing on economic, social, and governance (ESG) areas. The research conducted on this topic presents many studies, and it could be found that multi-criteria analysis is one of the most effective tools for assessing how sustainable companies actually are from an ESG perspective. Although there are many MCDA methodologies, the TOPSIS (Technique for Order Preference by Similarity to the Ideal Solution) method, designed and proposed by Hwang and Yoon, whose main use is related to the selection and ranking of the best alternatives, appears to be among the most widely used.

There are many research works carried out using this method: for example, mention may be made of the work of Rana and Sarva, which aimed to assess the financial performance of top-ranked ESG companies in the MSCI India ESG leaders index using the TOPSIS method within the MCDM framework. Or even the work of Rathi et al., which aims to rank companies by going to determine which company is superior based on ESG criteria. Of minority, but nevertheless also relevant, are studies in which other multicriteria methods are applied: the work of Ziolo et al. applies the PROMETHEE method (Preference Ranking Organization Method of Enrichment Evaluation), to evaluate 23 OECD countries that respect the Equator Principles according to seven groups of criteria defined for financial system assessment (financial depth, development, vulnerability, soundness, fragility, stability, and sustainability); Park and Jang use the AHP method to evaluate investment decisions against various ESG factors in the country, demonstrating how ESG elements are considered and how important they are to investors; Ojetunde et al. in their study aim to illustrate how the Fuzzy-TOPSIS technique, structured multi-criteria decision-making (MCDM) approach, can assist auditors in tailoring audit programs that prioritize environmental, social, and governance (ESG) considerations; Li et al. to evaluate the environmental, social, and governance (ESG) factors and policy options for green finance investment decisions in China, the fuzzy analytical hierarchy process (AHP) and fuzzy decision-making trial and evaluation laboratory (DEMATEL) techniques are employed. The fuzzy AHP method identifies and analyzes the most significant ESG

factors and subsub-factors to comprehensively understand sustainable investment in China. Furthermore, this study uses the fuzzy DEMATEL method to prioritize the main policy options for advancing sustainable development and green finance investment decisions in China; Rane et al. in their research paper, examine the effective utilization of a range of methods such as Analytic Hierarchy Process (AHP), Fuzzy Analytic Hierarchy Process (FAHP), Technique for Order of Preference by Similarity to Ideal Solution (TOPSIS), Elimination Et Choix Traduisant la Realité (ELECTRE), and VlseKriterijumska Optimizacija I Kompromisno Resenje (VIKOR) in the context of sustainability, from a theoretical point of view; Hoang et al. propose to define a classification of electronic companies using an innovative method that combines the Analytical Hierarchy Process (AHP) and Weighted Aggregated Sum Product Assessment (WASPAS) in a spherical fuzzy context, introduced to address uncertainties related to imprecision and subjectivity in ESG assessments; Reig-Mullor et al. implement a new hybrid methodology with AHP and TOPSIS techniques in a neutrosophic environment, applying the model to major oil and gas companies.

Although there are many studies related to the integration of ESG criteria in corporate valuations, few elaborate the application and comparison of multicriteria methods applied to a specific dataset of European companies, with the addition of also going to evaluate different data normalization techniques within the decision matrix (by default Vector Normalisation is used). The purpose of this paper is to deal with that topic: within it, 4 multicriteria decision-making methods are implemented to analyze the same dataset composed of 2412 European companies, with the aim of highlighting which are the best performing ESG businesses thus providing potential investors with a picture of the present situation, and to go to emphasize the robustness of the results obtained, through obtaining similar results among the various methods. This robustness is accentuated by the use of different normalisation techniques, going to justify why vector normalisation is the most widely used.

3. Sustainability and ESG (Environmental, Social, Governance) Ratings

The idea of an economic development that respects the environment began to take shape in 1970s, when it was recognized that the traditional growth model would, in the long term, lead to the degradation of the Earth's ecosystem. Since then, the concept of sustainability has become increasingly central to global debates and policies. Over the years, international efforts, such as the Paris Climate Agreement, have demonstrated that the planet's limits are tangible and that a new development model must necessarily be based on sustainability, with a forward-looking perspective. This new approach aims to foster an economy that develops responsibly, utilizing natural resources prudently and leveraging innovative technologies without causing environmental harm. Achieving this vision requires the participation of all stakeholders. Sustainability, and therefore sustainable development, is a complex concept subject to various interpretations. However, the most universally accepted definition is provided in the 1987 *Brundtland Report*, titled *"Our Common Future"*. This report emphasized the principles of equity both among present and future generations, defining sustainability as the ability to *"meet the needs of the present without compromising the ability of future generations to meet their own needs."* Ultimately, sustainability entails *"a constant, and preferably increasing, level of environmental, social, and economic well-being, as well as the prospect of leaving future generations a quality of life that is no less than that of the present"*. It is important to note, however, that the concept of sustainability is continuously evolving. The interactions between the ecological system and human systems can be influenced by rapid technological developments, which may alter constraints related, for example, to the use of energy resources. The *2030 Agenda* for Sustainable Development, adopted on September 25, 2015, by the United Nations General Assembly, is an action plan for people, the planet, and prosperity. At the heart of this agenda are 17 *Sustainable Development Goals* (SDGs), articulated into 169 specific targets, which represent an evolution of the *Millennium Development Goals* (MDGs) and aim to address the gaps left by their predecessors.

The *European Union Strategy for Sustainable Development*, adopted in 2011 in Gothenburg (Sweden), provided a concrete framework for coordinating sustainable development policies across three main dimensions: economic, social, and environmental. **Economic sustainability** refers to the ability of an economic system to generate income and employment sustainably; **environmental sustainability** focuses on protecting the ecosystem and renewing natural resources; **social sustainability** concerns the ability to ensure that human well-being conditions are equitably distributed. Each of these dimensions is fundamental to the concept of sustainable development, which focuses on addressing present needs without compromising the needs of future generations. An additional aspect can be added to these three dimensions: sustainable or responsible finance, which integrates environmental, social, and governance (ESG) principles into financial decision-making. This innovation is crucial for steering the financial system toward collective well-being and addressing climate risks, which are increasingly severe due to irreversible environmental damage.

Evaluations of Environmental, Social, and Governance factors, known as ESG, provide essential insights into the sustainability performance of a company or financial instrument. These data allow for a comprehensive view of companies' ability to generate value as well as their exposure to potential risks. The ESG dimensions represent fundamental criteria for verifying, measuring, monitoring, and supporting an organization's commitment to sustainability. The concept of ESG was first introduced in a 2004 report titled *"Who Cares Wins"*, a joint project of several financial institutions at the invitation of the United Nations (UN).

The ESG criteria are crucial because they offer a precise method, based on standardized and shared parameters, for measuring a company's environmental, social, and governance performance. However, the adoption of ESG practices varies by sector. Industries such as manufacturing, information technology, consumer discretionary goods, and materials generally show particularly high interest in ESG practices.

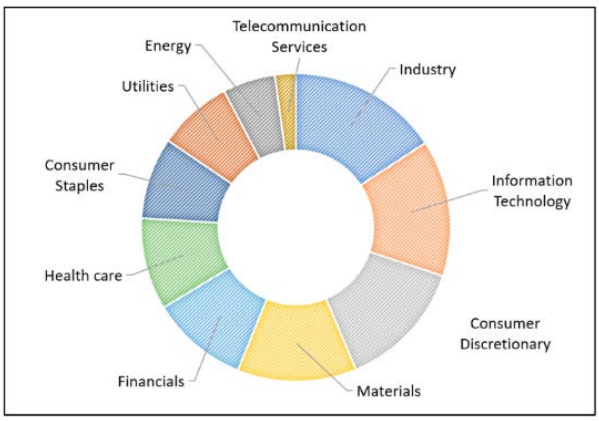

Figure 1. Adoption of ESG practices in different sectors.

Depending on the sector, the weights assigned to the relative importance of environmental, social, and governance factors vary. In particular, the *Environmental criterion* evaluates how a company operates in relation to the environment. Investors take into account aspects such as greenhouse gas emissions, for example, whether the company is actively reducing its CO_2 emissions or utilizing clean energy sources. They also consider the management of natural resources, questioning whether the company sustainably exploits resources like water and raw materials. Additionally, pollution and waste management are key elements, including how the company handles its waste and toxic emissions. The *social criterion*, on the other hand, concerns the company's impact on society, both internally and externally. This includes working conditions, such as whether the company ensures fair wages, workplace safety, and dignified working conditions for its employees. Human rights are another significant factor, with attention given to whether the company respects and promotes human rights across its supply chain. Furthermore, diversity and inclusion are increasingly central, examining whether the company encourages diversity within its workforce and leadership. Finally, the *governance criterion* focuses on the quality of corporate management and how the company is directed and controlled. It assesses the structure of the board of directors, considering aspects such as whether the board includes independent and diverse members and if there is a clear separation between the roles of CEO and chairperson. Ethical conduct and transparency are also crucial elements, evaluating whether the company adheres to ethical business practices and maintains transparency while actively avoiding corruption and fraud. Another relevant consideration is shareholder rights, particularly whether the company respects shareholders' ability to vote on important decisions.

4. Multi Criteria Decision Analisys (MCDA)

In the following chapter, several multicriteria methods applied in analysis are defined, namely: TOPSIS, PROMETHEE, SIR and VIKOR. In addition to this is also defined the normalisation process, which is the basis of the previously mentioned analysis methods, in particular: Vector Normalisation, Linear Normalisation, Row/Column Maximum Normalisation.

4.1 Normalisation

The goal of multicriteria analysis methods (MCDA) is to evaluate and prioritize a set of alternatives that best meet a given set of criteria. Criteria are a set of independent requirements or attributes that must be met by different alternatives. Each criterion can be measured in different units, e.g., degrees, kilograms or meters; but all must be normalized to obtain dimensionless ratings, i.e., a common numerical range/scale, to allow aggregation into a final score. Data normalisation is therefore an essential part of any decision-making process because it transforms input data into numerical, comparable data, allowing MCDM methods to be used to evaluate and rank alternatives, creating a level playing field for analysis. Each normalisation technique has its own pros and cons, and is chosen according to the nature of the problem and the objectives of the multicriteria analysis. For example, vector normalisation is useful for maintaining proportions between values, while linear normalisation is preferred for transforming data into a predefined range. Based on this, choosing the normalisation method, is a choice that can significantly affect the results of a multicriteria analysis, so it is important to select the technique best suited to the specific context. Among the most widely used is **Vector Normalisation**, which transforms the data so that the sum of the squares of the normalized values equals 1. This method is useful when you want the data to be normalized with respect to their overall magnitude.

This normalisation, for “profit type” criteria is defined as:

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

While, for “cost type” criteria is defined as:

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

Where xij corresponds to the i-th value of the alternative and the j-th value of the criterion in the starting decision matrix.

In addition to this normalization technique, 3 others have also been analyzed; namely: **Linear Normalization**, also known as *min-max normalization*, transforms the data so that all values are between 0 and 1; **Row/Column Maximum Normalization**, scales the values of each row/column relative to the maximum value of the sum of the rows/columns of the source matrix.

4.2 Multi-Criteria Methods

Multi Criteria Decision Making (MCDM), also known as Multi Criteria Decision Analysis (MCDA), refers to the methods used to prioritize, rank, or choose among a set of alternatives or options, taking into account different criteria. MCDM, in essence, involves four main components: the Alternatives (or individuals) to be evaluated or selected; the Criteria to evaluate and compare the alternatives, the nature of which may be qualitative or quantitative, with rating scales not necessarily identical to each other; the Weights representing the relative importance of the criteria; and the Decision-makers/other stakeholders whose preferences are to be considered. The MCDA is concerned with making sure that these 4 points are met so that the best possible analysis can be obtained.

MCDA Methods are applied according to four types of decision-making problems: **Choice Problem**: the goal is to choose the best option from a larger set of options (i.e., selecting the right person for a specific task); **Sorting Problem**: options are divided into ordered, predefined groups called categories. The goal is to group options with similar characteristics (i.e., to rank employees according to their job performance); **Ranking Problem**: the goal is to sort a set of options from the best to the worst by means of scores (e.g., to rank universities according to different criteria such as: quality of teaching, career opportunities...); **Description Problem**: the goal is to understand the characteristics of the decision problem by describing the set of possible options and their possible consequences.

Among the methods used in the analysis within the paper are: the **TOPSIS** (Technique for Order Preference by Similarities to the Ideal Solution), a multi-criteria decision analysis method, originally developed by Ching-Lai Hwang and Yoon in 1981 with subsequent refinements by Yoon in 1987, and Hwang, Lai and Liu in 1993. This method is based on the idea that the optimal alternative should have the shortest geometric distance to the positive ideal solution (PIS) and the longest geometric distance to the negative ideal solution (NIS); **VIKOR** (VIseKriterijumska Optimizacija I Kompromisno Resenje), also known as the compromise ranking method, was first proposed by Serafim Opricovic in 1979 in his doctoral dissertation to solve decision problems with conflicting and non-commensurable criteria. The method assumes that a compromise is an acceptable solution for conflict resolution, and that the decision maker desires a solution that is as close to the ideal as possible. For this, alternatives are evaluated taking into account all established criteria. This method is thus inspired by TOPSIS theory, in which the alternative that comes closest to the ideal solution is sought; **PROMETHEE** (Preference Ranking Organization METHod for Enrichment Evaluations) was first introduced by Professor Jean-Pierre Brans in 1982. It was later developed and implemented by Professor Jean-Pierre Brans and Professor Bertrand Mareschal, including extensions such as GAIA. This method represents a family of methods as PROMETHEE has been refined and extended over the years. The main methodologies range from PROMETHEE I to VI as well as versions with intervals and fuzzy numbers. The goal of this method is to rank alternatives through relative flow, given by the difference between positive flow and negative flow by going directly to compare the alternatives under analysis through a preference function for each criterion; **SIR** (Superiority and Inferiority Ranking), developed by Xu in 2001, is a technique that is still not widely used but deserves attention for its potential. Although it shares many similarities with more established methodologies such as TOPSIS and PROMETHEE, SIR can be seen as an advanced extension of PROMETHEE. The goal of this method is to go about ranking alternatives by dominance relationships by going to compare them in pairs as in the PROMETHEE method thus going on to determine how much one alternative is *superior or inferior* to the other.

5. Evaluation of European countries using MCDA

In order to compare the properties of the different ranking methods mentioned in the previous chapter, it was deemed appropriate to apply them to a Dataset developed for the ranking of European companies by LSEG (*London Stock Exchange Group*), a global provider of infrastructure and financial markets, with a prominent focus on data delivery. The Dataset provides a ranking of 2412 European companies based on 2021 data. The results processed by LSEG, organized in descending order according to ESG criteria, are obtained from the analysis of the three parameters shown in the columns: *Environmental Pillar Score*, *Social Pillar Score* and *Governance Pillar Score*. This ranking is the result of highly detailed processes, preceded by a thorough analysis: the weights assigned to the three criteria vary, in fact, according to the industry sector to which the company belongs (*Industry Group*). An example of this variability can be observed in *Figure 2*, where, in 7th place, is *SAP SE* (Category: *Software & IT Services*), which, despite having a significantly lower *E* score than the companies below, achieves a higher overall *ESG Score* than *Shell PLC* (Category: *Oil & Gas*), which has higher values in two out of three criteria, and an *S* score only slightly lower. This result can be attributed to the fact that for the *Software & IT Services* category very little weight was assigned to criterion *E*, giving greater importance to the remaining two criteria.

Rank	Company Name	HQ	Industry Group	Mkt. Cap (	ESG Score	mbined	Environmental Pillar Score	Social Pillar Score	Governance Pillar Score
1	AstraZeneca PLC	GB	Pharmaceuticals	$244,336	95,57	48,15	93,02	97,24	94,94
2	GSK plc	GB	Pharmaceuticals	$84,106	94,57	75,59	86,02	96,63	97,75
3	BNP Paribas SA	FR	Banking Services	$71,557	94,54	67,32	94,65	95,70	92,90
4	British American Tobacco plc	GB	Food & Tobacco	$67,897	94,25	59,32	95,62	93,77	93,58
5	Roche Holding AG	CH	Pharmaceuticals	$226,335	94,14	88,25	94,11	97,75	88,78
6	Abb Ltd	CH	Machinery, Tools, Heavy Vehicles, Trains & Ships	$105,186	93,99	93,99	97,15	94,05	90,14
7	SAP SE	DE	Software & IT Services	$231,036	93,35	84,83	76,38	97,18	95,15
8	Shell PLC	GB	Oil & Gas	$219,056	92,78	48,79	91,06	92,59	95,63
9	Intesa Sanpaolo SpA	IT	Banking Services	$65,838	92,74	83,74	96,89	93,66	89,81
10	Mercedes-Benz Group AG	DE	Automobiles & Auto Parts	$72,793	92,71	50,39	95,13	89,20	95,31
11	Banco Santander SA	ES	Banking Services	$74,676	92,55	56,18	89,03	94,86	90,77
12	STMicroelectronics NV	NL	Semiconductors & Semiconductor Equipment	$38,744	92,16	92,16	94,82	92,94	87,67
13	Snam SpA	IT	Oil & Gas Related Equipment and Services	$15,219	91,89	91,89	96,47	88,54	91,30
14	Allianz SE	DE	Insurance	$107,132	91,58	54,76	93,72	89,25	93,58
15	BASF SE	DE	Chemicals	$42,822	91,57	49,19	94,23	92,78	84,82

Figure 2. Top 15 European Companies in the LSEG Ranking.

Based on this ranking, it was decided to replicate the classification process by implementing the following Python methods: *TOPSIS*, *VIKOR*, *SIR*, and *PROMETHEE_II*. The implementation in Python was necessary because of the large number of alternatives in the Dataset (2412).

After defining the alternatives, the evaluation criteria were established, which in this case are three: *Environmental Pillar Score*, *Social Pillar Score*, and

Governance Pillar Score. In order to obtain a more generic ranking, the weights assigned to each criterion were considered equal: *1/3, 1/3, 1/3*, respectively, so that their sum was equal to 1; all criteria were treated as a *benefit criterion*, thus maximized. Next, for the PROMETHEE_II and SIR methods, the simplest preference function, namely the *Usual Criterion*, was chosen.

The following are part of the rankings obtained from the normalized decision matrix through: Vector Normalisation, Linear Normalisation, Row/Column Maximum Normalisation to which the same process is added without performing any kind of normalisation.

	Ranking TOPSIS (NormVet):	Ranking PROMETHEE (NormVet):
1	AstraZeneca PLC	AstraZeneca PLC
2	British American Tobacco plc	BNP Paribas SA
3	BNP Paribas SA	British American Tobacco plc
4	Abb Ltd	Abb Ltd
5	Mercedes-Benz Group AG	Intesa Sanpaolo SpA
6	Shell PLC	Roche Holding AG
7	Intesa Sanpaolo SpA	Shell PLC
8	Roche Holding AG	Mercedes-Benz Group AG
9	Allianz SE	GSK plc
10	Assicurazioni Generali SpA	Banco Santander SA
11	Snam SpA	STMicroelectronics NV
12	STMicroelectronics NV	Snam SpA
13	GSK plc	Allianz SE
14	Banco Santander SA	Assicurazioni Generali SpA
15	Volvo AB	Volvo AB
⋮	⋮	⋮
2398	Bijou Brigitte modische Accessoires AG	Envitec Biogas AG
2399	Tivoli A/S	Prevas AB
2400	TraWell Co SpA	Tivoli A/S
2401	Agrogeneration SA	Bijou Brigitte modische Accessoires AG
2402	Dewhurst Group PLC	Airesis SA
2403	Airesis SA	Acconeer AB
2404	Syn hf	Syn hf
2405	Acconeer AB	TraWell Co SpA
2406	Traction AB	Gevelot SA
2407	Gevelot SA	Baltic Classifieds Group PLC
2408	Eeii AG	Eeii AG
2409	Muehlhan AG	Muehlhan AG
2410	Baltic Classifieds Group PLC	Traction AB
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

	Ranking SIR (NormVet):	Ranking VIKOR (NormVet):
1	AstraZeneca PLC	AstraZeneca PLC
2	BNP Paribas SA	British American Tobacco plc
3	British American Tobacco plc	BNP Paribas SA
4	Abb Ltd	Shell PLC
5	Intesa Sanpaolo SpA	Abb Ltd
6	Roche Holding AG	Intesa Sanpaolo SpA
7	Shell PLC	Mercedes-Benz Group AG
8	Mercedes-Benz Group AG	Roche Holding AG
9	GSK plc	Allianz SE
10	Banco Santander SA	GSK plc
11	Allianz SE	Snam SpA
12	STMicroelectronics NV	Banco Santander SA
13	Snam SpA	Assicurazioni Generali SpA
14	Assicurazioni Generali SpA	STMicroelectronics NV
15	Volvo AB	BP PLC
⋮	⋮	⋮
2398	Bijou Brigitte modische Accessoires AG	Agrogeneration SA
2399	Envitec Biogas AG	Envitec Biogas AG
2400	Prevas AB	Prevas AB
2401	Tivoli A/S	Tivoli A/S
2402	Airesis SA	TraWell Co SpA
2403	Syn hf	Syn hf
2404	TraWell Co SpA	Airesis SA
2405	Acconeer AB	Acconeer AB
2406	Gevelot SA	Gevelot SA
2407	Eeii AG	Eeii AG
2408	Traction AB	Muehlhan AG
2409	Baltic Classifieds Group PLC	Traction AB
2410	Muehlhan AG	Baltic Classifieds Group PLC
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

Figure 3. Ranking TOPSIS, PROMETHEE, VIKOR and SIR with Vector Normalisation.

	Ranking TOPSIS (NoNorm):	Ranking PROMETHEE (NoNorm):
1	AstraZeneca PLC	AstraZeneca PLC
2	BNP Paribas SA	BNP Paribas SA
3	British American Tobacco plc	British American Tobacco plc
4	Abb Ltd	Abb Ltd
5	Shell PLC	Intesa Sanpaolo SpA
6	Intesa Sanpaolo SpA	Roche Holding AG
7	Mercedes-Benz Group AG	Shell PLC
8	Roche Holding AG	Mercedes-Benz Group AG
9	Allianz SE	GSK plc
10	Assicurazioni Generali SpA	Banco Santander SA
11	GSK plc	STMicroelectronics NV
12	Snam SpA	Snam SpA
13	Banco Santander SA	Allianz SE
14	STMicroelectronics NV	Assicurazioni Generali SpA
15	Volvo AB	Volvo AB
⋮	⋮	⋮
2398	Bank of Greece	Envitec Biogas AG
2399	Tivoli A/S	Prevas AB
2400	TraWell Co SpA	Tivoli A/S
2401	Agrogeneration SA	Bijou Brigitte modische Accessoires AG
2402	Dewhurst Group PLC	Airesis SA
2403	Airesis SA	Acconeer AB
2404	Acconeer AB	Syn hf
2405	Syn hf	TraWell Co SpA
2406	Traction AB	Gevelot SA
2407	Gevelot SA	Baltic Classifieds Group PLC
2408	Eeii AG	Eeii AG
2409	Muehlhan AG	Muehlhan AG
2410	Baltic Classifieds Group PLC	Traction AB
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

	Ranking SIR (NoNorm):	Ranking VIKOR (NoNorm):
1	AstraZeneca PLC	AstraZeneca PLC
2	BNP Paribas SA	British American Tobacco plc
3	British American Tobacco plc	BNP Paribas SA
4	Abb Ltd	Shell PLC
5	Intesa Sanpaolo SpA	Abb Ltd
6	Roche Holding AG	Intesa Sanpaolo SpA
7	Shell PLC	Mercedes-Benz Group AG
8	Mercedes-Benz Group AG	Roche Holding AG
9	GSK plc	Allianz SE
10	Banco Santander SA	GSK plc
11	Allianz SE	Snam SpA
12	STMicroelectronics NV	Banco Santander SA
13	Snam SpA	Assicurazioni Generali SpA
14	Assicurazioni Generali SpA	STMicroelectronics NV
15	Volvo AB	BP PLC
⋮	⋮	⋮
2398	Bijou Brigitte modische Accessoires AG	Agrogeneration SA
2399	Envitec Biogas AG	Envitec Biogas AG
2400	Prevas AB	Prevas AB
2401	Tivoli A/S	Tivoli A/S
2402	Airesis SA	TraWell Co SpA
2403	Syn hf	Syn hf
2404	TraWell Co SpA	Airesis SA
2405	Acconeer AB	Acconeer AB
2406	Gevelot SA	Gevelot SA
2407	Eeii AG	Eeii AG
2408	Traction AB	Muehlhan AG
2409	Baltic Classifieds Group PLC	Traction AB
2410	Muehlhan AG	Baltic Classifieds Group PLC
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

Figure 4. Ranking TOPSIS, PROMETHEE, VIKOR and SIR with No Normalisation.

	Ranking TOPSIS (NormLin):	Ranking PROMETHEE (NormLin):
1	AstraZeneca PLC	AstraZeneca PLC
2	BNP Paribas SA	BNP Paribas SA
3	British American Tobacco plc	British American Tobacco plc
4	Abb Ltd	Abb Ltd
5	Shell PLC	Intesa Sanpaolo SpA
6	Intesa Sanpaolo SpA	Roche Holding AG
7	Mercedes-Benz Group AG	Shell PLC
8	Roche Holding AG	Mercedes-Benz Group AG
9	Allianz SE	GSK plc
10	Assicurazioni Generali SpA	Banco Santander SA
11	GSK plc	STMicroelectronics NV
12	Snam SpA	Snam SpA
13	Banco Santander SA	Allianz SE
14	STMicroelectronics NV	Assicurazioni Generali SpA
15	Volvo AB	Volvo AB
⋮	⋮	⋮
2398	Bank of Greece	Envitec Biogas AG
2399	Tivoli A/S	Prevas AB
2400	TraWell Co SpA	Tivoli A/S
2401	Agrogeneration SA	Bijou Brigitte modische Accessoires AG
2402	Dewhurst Group PLC	Airesis SA
2403	Airesis SA	Acconeer AB
2404	Acconeer AB	Syn hf
2405	Syn hf	TraWell Co SpA
2406	Traction AB	Gevelot SA
2407	Gevelot SA	Baltic Classifieds Group PLC
2408	Eeii AG	Eeii AG
2409	Muehlhan AG	Muehlhan AG
2410	Baltic Classifieds Group PLC	Traction AB
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

	Ranking SIR (NormLin):	Ranking VIKOR (NormLin):
1	AstraZeneca PLC	AstraZeneca PLC
2	BNP Paribas SA	British American Tobacco plc
3	British American Tobacco plc	BNP Paribas SA
4	Abb Ltd	Shell PLC
5	Intesa Sanpaolo SpA	Abb Ltd
6	Roche Holding AG	Intesa Sanpaolo SpA
7	Shell PLC	Mercedes-Benz Group AG
8	Mercedes-Benz Group AG	Roche Holding AG
9	GSK plc	Allianz SE
10	Banco Santander SA	GSK plc
11	Allianz SE	Snam SpA
12	STMicroelectronics NV	Banco Santander SA
13	Snam SpA	Assicurazioni Generali SpA
14	Assicurazioni Generali SpA	STMicroelectronics NV
15	Volvo AB	BP PLC
⋮	⋮	⋮
2398	Bijou Brigitte modische Accessoires AG	Agrogeneration SA
2399	Envitec Biogas AG	Envitec Biogas AG
2400	Prevas AB	Prevas AB
2401	Tivoli A/S	Tivoli A/S
2402	Airesis SA	TraWell Co SpA
2403	Syn hf	Syn hf
2404	TraWell Co SpA	Airesis SA
2405	Acconeer AB	Acconeer AB
2406	Gevelot SA	Gevelot SA
2407	Eeii AG	Eeii AG
2408	Traction AB	Muehlhan AG
2409	Baltic Classifieds Group PLC	Traction AB
2410	Muehlhan AG	Baltic Classifieds Group PLC
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

Figure 5. Ranking TOPSIS, PROMETHEE, VIKOR and SIR with Linear Normalisation.

	Ranking TOPSIS (NormMaxRi):	Ranking PROMETHEE (NormMaxRi):
1	AstraZeneca PLC	AstraZeneca PLC
2	BNP Paribas SA	BNP Paribas SA
3	British American Tobacco plc	British American Tobacco plc
4	Abb Ltd	Abb Ltd
5	Shell PLC	Intesa Sanpaolo SpA
6	Intesa Sanpaolo SpA	Roche Holding AG
7	Mercedes-Benz Group AG	Shell PLC
8	Roche Holding AG	Mercedes-Benz Group AG
9	Allianz SE	GSK plc
10	Assicurazioni Generali SpA	Banco Santander SA
11	GSK plc	STMicroelectronics NV
12	Snam SpA	Snam SpA
13	Banco Santander SA	Allianz SE
14	STMicroelectronics NV	Assicurazioni Generali SpA
15	Volvo AB	Volvo AB
⋮	⋮	⋮
2398	Bank of Greece	Envitec Biogas AG
2399	Tivoli A/S	Prevas AB
2400	TraWell Co SpA	Tivoli A/S
2401	Agrogeneration SA	Bijou Brigitte modische Accessoires AG
2402	Dewhurst Group PLC	Airesis SA
2403	Airesis SA	Acconeer AB
2404	Acconeer AB	Syn hf
2405	Syn hf	TraWell Co SpA
2406	Traction AB	Gevelot SA
2407	Gevelot SA	Baltic Classifieds Group PLC
2408	Eeii AG	Eeii AG
2409	Muehlhan AG	Muehlhan AG
2410	Baltic Classifieds Group PLC	Traction AB
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

	Ranking SIR (NormMaxRi):	Ranking VIKOR (NormMaxRi):
1	AstraZeneca PLC	AstraZeneca PLC
2	BNP Paribas SA	British American Tobacco plc
3	British American Tobacco plc	BNP Paribas SA
4	Abb Ltd	Shell PLC
5	Intesa Sanpaolo SpA	Abb Ltd
6	Roche Holding AG	Intesa Sanpaolo SpA
7	Shell PLC	Mercedes-Benz Group AG
8	Mercedes-Benz Group AG	Roche Holding AG
9	GSK plc	Allianz SE
10	Banco Santander SA	GSK plc
11	Allianz SE	Snam SpA
12	STMicroelectronics NV	Banco Santander SA
13	Snam SpA	Assicurazioni Generali SpA
14	Assicurazioni Generali SpA	STMicroelectronics NV
15	Volvo AB	BP PLC
⋮	⋮	⋮
2398	Bijou Brigitte modische Accessoires AG	Agrogeneration SA
2399	Envitec Biogas AG	Envitec Biogas AG
2400	Prevas AB	Prevas AB
2401	Tivoli A/S	Tivoli A/S
2402	Airesis SA	TraWell Co SpA
2403	Syn hf	Syn hf
2404	TraWell Co SpA	Airesis SA
2405	Acconeer AB	Acconeer AB
2406	Gevelot SA	Gevelot SA
2407	Eeii AG	Eeii AG
2408	Traction AB	Muehlhan AG
2409	Baltic Classifieds Group PLC	Traction AB
2410	Muehlhan AG	Baltic Classifieds Group PLC
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

Figure 6. Ranking TOPSIS, PROMETHEE, VIKOR and SIR with Row Maximum Normalisation.

	Ranking TOPSIS (NormMaxCo):	Ranking PROMETHEE (NormMaxCo):
1	AstraZeneca PLC	AstraZeneca PLC
2	BNP Paribas SA	BNP Paribas SA
3	British American Tobacco plc	British American Tobacco plc
4	Abb Ltd	Abb Ltd
5	Shell PLC	Intesa Sanpaolo SpA
6	Intesa Sanpaolo SpA	Roche Holding AG
7	Mercedes-Benz Group AG	Shell PLC
8	Roche Holding AG	Mercedes-Benz Group AG
9	Allianz SE	GSK plc
10	Assicurazioni Generali SpA	Banco Santander SA
11	GSK plc	STMicroelectronics NV
12	Snam SpA	Snam SpA
13	Banco Santander SA	Allianz SE
14	STMicroelectronics NV	Assicurazioni Generali SpA
15	Volvo AB	Volvo AB
⋮	⋮	⋮
2398	Bank of Greece	Envitec Biogas AG
2399	Tivoli A/S	Prevas AB
2400	TraWell Co SpA	Tivoli A/S
2401	Agrogeneration SA	Bijou Brigitte modische Accessoires AG
2402	Dewhurst Group PLC	Airesis SA
2403	Airesis SA	Acconeer AB
2404	Acconeer AB	Syn hf
2405	Syn hf	TraWell Co SpA
2406	Traction AB	Gevelot SA
2407	Gevelot SA	Baltic Classifieds Group PLC
2408	Eeii AG	Eeii AG
2409	Muehlhan AG	Muehlhan AG
2410	Baltic Classifieds Group PLC	Traction AB
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

	Ranking SIR (NormMaxCo):	Ranking VIKOR (NormMaxCo):
1	AstraZeneca PLC	AstraZeneca PLC
2	BNP Paribas SA	British American Tobacco plc
3	British American Tobacco plc	BNP Paribas SA
4	Abb Ltd	Shell PLC
5	Intesa Sanpaolo SpA	Abb Ltd
6	Roche Holding AG	Intesa Sanpaolo SpA
7	Shell PLC	Mercedes-Benz Group AG
8	Mercedes-Benz Group AG	Roche Holding AG
9	GSK plc	Allianz SE
10	Banco Santander SA	GSK plc
11	Allianz SE	Snam SpA
12	STMicroelectronics NV	Banco Santander SA
13	Snam SpA	Assicurazioni Generali SpA
14	Assicurazioni Generali SpA	STMicroelectronics NV
15	Volvo AB	BP PLC
⋮	⋮	⋮
2398	Bijou Brigitte modische Accessoires AG	Agrogeneration SA
2399	Envitec Biogas AG	Envitec Biogas AG
2400	Prevas AB	Prevas AB
2401	Tivoli A/S	Tivoli A/S
2402	Airesis SA	TraWell Co SpA
2403	Syn hf	Syn hf
2404	TraWell Co SpA	Airesis SA
2405	Acconeer AB	Acconeer AB
2406	Gevelot SA	Gevelot SA
2407	Eeii AG	Eeii AG
2408	Traction AB	Muehlhan AG
2409	Baltic Classifieds Group PLC	Traction AB
2410	Muehlhan AG	Baltic Classifieds Group PLC
2411	Sandpiper Digital Payments AG	Sandpiper Digital Payments AG
2412	ISPD Network SA	ISPD Network SA

Figure 7. Ranking TOPSIS, PROMETHEE, VIKOR and SIR with Column Maximum Normalisation.

As can be seen from the rankings above, the results appear to be very similar, with at most some slight changes in position probably due to very close scores, however not very significant due to the large number of alternatives analyzed. From a general analysis, we can see that the top positions in the ranking are mainly occupied by pharmaceutical, financial services, and technology companies; this indicates that these sectors may have a strong focus on sustainability criteria, particularly in terms

of governance and social impact. In addition, the top positions include companies from several European countries (mainly the United Kingdom, France, Switzerland, and Germany); this reflects the commitment to sustainability in various national contexts, with leading companies appearing to be particularly active in Western Europe. What is more, the list covers a wide range of industries, totaling fifty-seven, and this diversity shows that sustainability is important in each, despite their operational differences. Putting attention to the companies placed at the bottom of the ranking instead, one can denote how they have much lower market capitalization than the companies in the top positions, with many being under $1 billion and some even under $100 million. This may limit their ability to invest in ESG initiatives, as they may prioritize economic survival and financial growth rather than long-term sustainability; we also note that the predominant sectors here include investment banking, commercial services, machinery, software and IT services, renewable energy, and electric utilities. These sectors may have structural or operational difficulties in integrating ESG practices, or may not have the same level of pressure from investors as other sectors such as pharmaceuticals or banking. Finally, it is worth noting that again, the provenance of these companies is primarily Western Europe, with Switzerland, Germany, the United Kingdom, and Sweden; this suggests that their low ESG performance is not solely related to weak regulations or a lack of government focus on sustainability.

Looking at the top 10 best companies at the ESG level, we note how:

- *AstraZeneca* remains in first place regardless of the criterion used, while other pharmaceutical companies, such as *GSK* and *Roche Holding*, vary in position while still remaining among the best analyzed: this could be due to strong sustainability policies regarding public health, responsible research, and resource management showing that large pharmaceutical companies are making significant efforts in the ESG area;

- Banks, such as *BNP Paribas* (second/third position), *Intesa Sanpaolo*, and *Banco Santander* show how the financial services sector has increasingly emphasized sustainable finance and socially responsible investing. This may explain their good results, as governance and social impact play a crucial role in their operations;

- The company *Shell PLC* turns out to be a special case. Its ranking, which ranges from fourth to seventh place, decidedly high for a company in the oil sector, denotes

a significant commitment to the energy transition and the development of renewable energy, although the core business is still in an area with high environmental impact;

- Companies such as *Mercedes-Benz* and *Abb Ltd*, part of the automotive, machinery, and heavy-duty vehicle sectors, although they may still suffer from challenges related to production and energy consumption, as well as supply chain and CO2 emissions, are still among the most sustainable companies in the industry;

- Also in the top 3 of all rankings is *British America Tobacco*: despite its controversial business, this high ranking may reflect excellent management of governance issues and implementation of socially responsible practices, despite the fact that the core business is often seen as environmentally and socially negative;

- Companies in the insurance sector such as *Allianz SE* and *Assicurazioni Generali SpA* fall in the top 10 only by TOPSIS criteria (with the VIKOR only Allianz appears in ninth place); this shows significant commitment in this area as well, which is particularly important for a sector that plays a crucial role in managing and hedging risks, including those arising from climate change.

Putting the focus instead on the bottom 10:

- *Syn hf* company in the telecommunications sector is a clear example of how, while this sector has a relatively low environmental impact compared to other sectors, it can still suffer in terms of sustainable resource management and social responsibility;

- *Airesis SA*, *Eeii AG*, and *Traction AB*, the Investment Banking and Investment Holding Companies sectors, respectively, rank low probably due to the fact that they invest in companies operating in sectors with high environmental impact or poor governance, as well as lack of transparency or unethical investment management;

- The electronics sector to which *Acconeer AB* belongs is often criticized for its use of unsustainable materials, inadequate disposal of e-waste, and intensive use of energy. In addition, concerns related to workers' rights and working conditions in supply chains are key factors in this industry;

- The company *Gevelot SA*, unlike *Abb Ltd* mentioned earlier (heavy machinery and vehicle manufacturing sector such as trains and ships), due to intensive energy use, high emissions and industrial waste generation, as well as occupational health and safety concerns, has a very difficult time ranking higher in the ESG sphere;

- *Muehlhan AG* is confirmation that the construction industry is notorious for its environmental impact, due to consumption of natural resources, waste production and greenhouse gas emeissions, in addition to the issue of worker safety management, a crucial aspect for ESG assessments;

- *Baltic Classifieds Group PLC*, a company in the Software and IT Services sector occupies a decidedly low position (third to last in the TOPSIS and VIKOR rankings) probably due to its failure to demonstrate responsible management in areas such as energy use and privacy and data management. On the social side, its low score is due to lack of diversity in staff and internal policies;

- *Sandpiper Digital Payments AG*, office equipment sector, may have environmental problems related to the use of non-recyclable materials and product lifecycle impacts (production and disposal), which is why it ranks second to last in the four rankings above;

- *ISPD Network SA*, Media and Publishing sector, consistently ranks as the worst company, regardless of the standardization and criterion applied. Companies in this sector face ESG challenges related to transparency of information, ethics in content, and management of workers' rights. So, weak governance or lack of clear policies in these areas could be behind the very low score.

Comparing the rankings obtained with the starting one made by LSEG, we can immediately see that the first and last positions turn out to be very similar (*AstraZeneca PLC* is confirmed in first place, as are *Sandpiper Digital Payments AG* and *ISPD Network SA* in the last positions) despite the assignment of different weights between industry groups. A clear case where this diversification of weights is noticeable is for *SAP SE*, a company in the Software and IT Services sector, which, assigning equal scores to the three criteria, from the seventh starting position, undergoes a decline in all four applied methods, coming in a position that ranges between 33rd and 44th. This is due, as mentioned at the beginning of Chapter 3, to the fact that for companies in this sector, Criterion *E* turns out to have a very

low relevance compared to the remaining two criteria, with a weight of 14% (Criterion *S* 39%, Criterion *G* 46%), and this allows the hierarchies to climb.

Analyzing the weights LSEG assigned to the three criteria we note that:

- The minimum weight for criterion **E** is 9% for companies in the *Communications & Networking* and *Financial Technology & Infrastructure* sectors, the maximum weight is 45% for companies in the Paper & Forest Products sector, for an average value of 29%;

- The minimum weight for criterion **S** is 24% for companies in the *Investment Holding Companies* sector, the maximum weight is 53% for companies in the *Telecommunications Services* and *Textiles & Apparel* sectors, for an average value of 40%;

- The minimum weight for criterion **G** is 22% for companies in the *Chemicals* sector, the maximum weight is 53% for companies in the *Collective Investments* sector, for an average value of 31%.

This shows the fact that using equal weights for the three criteria does not deviate much from what an “average subject” might be.

Rank	Company Name	HQ	Industry Group	t. Cap (	ESG Score	mbine	Environmental Pillar Score	Social Pillar Score	Governance Pillar Score
1	AstraZeneca PLC	GB	Pharmaceuticals	$244,336	96,57	48,15	93,02	97,24	94,94
2	GSK plc	GB	Pharmaceuticals	$84,106	94,57	75,59	86,02	96,63	97,75
3	BNP Paribas SA	FR	Banking Services	$71,557	94,54	67,32	94,65	95,70	92,90
4	British American Tobacco plc	GB	Food & Tobacco	$67,097	94,25	59,32	95,62	93,77	93,56
5	Roche Holding AG	CH	Pharmaceuticals	$226,335	94,14	88,26	94,11	97,75	88,78
6	Abb Ltd	CH	Machinery, Tools, Heavy Vehicles, Trains & Ships	$105,186	93,99	93,99	97,15	94,05	90,14
7	SAP SE	DE	Software & IT Services	$231,036	93,35	84,83	78,38	97,18	95,15
8	Shell PLC	GB	Oil & Gas	$219,056	92,76	48,79	91,06	92,59	95,63
9	Intesa Sanpaolo SpA	IT	Banking Services	$65,838	92,74	83,74	96,89	93,66	89,81
10	Mercedes-Benz Group AG	DE	Automobiles & Auto Parts	$72,793	92,71	50,39	95,13	89,20	95,31
11	Banco Santander SA	ES	Banking Services	$74,676	92,55	56,18	89,03	94,86	90,77
12	STMicroelectronics NV	NL	Semiconductors & Semiconductor Equipment	$38,744	92,16	92,16	94,82	92,94	87,67
13	Snam SpA	IT	Oil & Gas Related Equipment and Services	$15,219	91,89	91,89	96,47	88,54	91,30
14	Allianz SE	DE	Insurance	$107,132	91,58	84,76	93,72	89,25	93,58
15	BASF SE	DE	Chemicals	$42,822	91,57	49,19	94,23	92,78	84,82
⋮									
2398	TraWell Co SpA	IT	Transport Infrastructure	$21	3,50	3,50	0,00	7,41	1,18
2399	Dewhurst Group PLC	GB	Machinery, Tools, Heavy Vehicles, Trains & Ships	$89	3,44	3,44	1,35	4,30	4,80
2400	Syn hf	IS	Telecommunications Services	$59	3,26	3,26	0,00	3,97	4,33
2401	Tivoli A/S	DK	Hotels & Entertainment Services	$584	3,23	3,23	0,00	1,81	8,28
2402	Agrogeneration SA	FR	Food & Tobacco	$11	2,80	2,80	2,14	0,96	6,72
2402	Envitec Biogas AG	DE	Electric Utilities & IPPs	$573	2,80	2,80	0,00	1,84	9,19
2404	Acconeer AB	SE	Electronic Equipment & Parts	$39	2,45	2,45	0,00	5,21	2,65
2405	Bank of Greece	GR	Banking Services	$289	2,22	2,22	8,09	0,42	2,35
2406	Gevelot SA	FR	Machinery, Tools, Heavy Vehicles, Trains & Ships	$185	1,80	1,80	0,00	2,99	2,39
2407	Baltic Classifieds Group PLC	LT	Software & IT Services	$1,408	1,73	1,73	0,00	2,78	1,34
2408	Eeii AG	CH	Investment Holding Companies	$5	1,59	1,59	0,00	2,77	2,48
2409	Muehlhan AG	DE	Construction & Engineering	$31	1,47	1,47	0,00	2,25	2,45
2410	Tracton AB	SE	Investment Holding Companies	$354	1,23	1,23	0,00	4,14	0,54
2411	Sandpiper Digital Payments AG	CH	Office Equipment	$2	1,00	1,00	0,00	0,94	2,18
2412	ISPD Network SA	ES	Media & Publishing	$50	0,74	0,74	0,00	1,06	0,56

Figure 8. First/Last European Companies in the LSEG Ranking.

5.1 Analysis Companies in the *Pharmaceutical* Sector

In order to verify whether or not the analyzed ranking methods are indeed valid for ranking companies at the ESG level, it was deemed appropriate to conduct a more in-depth analysis by studying only one sector, the Pharmaceutical sector, thus avoiding distinctions of weights among different sectors. This sector includes 63 companies, and the values assigned to the three criteria in percentages are: 22% for criterion E, 46% for criterion S, and 31% for criterion G, the same values applied by LSEG. The normalisation used for this study, is vector normalisation. Vector normalisation was considered primarily for several features: at first Greater robustness to outliers, reducing the effect of outliers or very high/low values; Preservation of proportions, an extremely important aspect in methods such as TOPSIS, where relative distances from positive and negative ideals are compared; Applicability to datasets with many alternatives because it handles diversity of values well without requiring too much manual editing or adjustment; Better handling of differences in scale (although not very influential in this case), balancing the importance of criteria with very large and very small values without one criterion dominating over the others.

The results obtained are:

Pos.	TOPSIS	VIKOR	PROMETHEE	SIR	LSEG
1	AstraZeneca PLC	AstraZeneca PLC	Roche Holding AG	Roche Holding AG	AstraZeneca PLC
2	GSK plc	GSK plc	AstraZeneca PLC	AstraZeneca PLC	GSK plc
3	Roche Holding AG	Roche Holding AG	GSK plc	GSK plc	Roche Holding AG
4	Sanofi SA	Sanofi SA	Bayer AG	Bayer AG	Sanofi SA
5	Bayer AG	Bayer AG	Sanofi SA	Sanofi SA	Bayer AG
6	Merck KGaA	Merck KGaA	Merck KGaA	Merck KGaA	Merck KGaA
7	Novartis AG	Novartis AG	Novartis AG	Novartis AG	Novartis AG
8	Ucb SA	Ucb SA	Ucb SA	Ucb SA	Ucb SA
9	Novo Nordisk A/S	Novo Nordisk A/S	Novo Nordisk A/S	Novo Nordisk A/S	Novo Nordisk A/S
10	Hikma Pharmaceuticals PLC	Hikma Pharmaceuticals PLC	Hikma Pharmaceuticals PLC	Hikma Pharmaceuticals PLC	Orion Oyj
11	Orion Oyj	Recordati Industria Chimica e Farmaceutica SpA	Orion Oyj	Orion Oyj	Hikma Pharmaceuticals PLC
12	Recordati Industria Chimica e Farmaceutica SpA	Orion Oyj	Recordati Industria Chimica e Farmaceutica SpA	Richter Gedeon Vegyeszeti Gyar Nyrt	Recordati Industria Chimica e Farmaceutica SpA
13	Richter Gedeon Vegyeszeti Gyar Nyrt	Richter Gedeon Vegyeszeti Gyar Nyrt	Richter Gedeon Vegyeszeti Gyar Nyrt	Recordati Industria Chimica e Farmaceutica SpA	Richter Gedeon Vegyeszeti Gyar Nyrt
14	Siegfried Holding AG	Pharma Mar SA	Siegfried Holding AG	Siegfried Holding AG	Grifols SA
15	Pharma Mar SA	Siegfried Holding AG	Galenica AG	Galenica AG	Galenica AG
16	Galenica AG	Swedish Orphan Biovitrum AB (publ)	Ipsen SA	Pharma Mar SA	Pharma Mar SA
17	Swedish Orphan Biovitrum AB (publ)	Galenica AG	Pharma Mar SA	Ipsen SA	Siegfried Holding AG
18	Krka dd Novo Mesto	Krka dd Novo Mesto	Krka dd Novo Mesto	Krka dd Novo Mesto	Swedish Orphan Biovitrum AB (publ)
19	Grifols SA	Grifols SA	Swedish Orphan Biovitrum AB (publ)	Swedish Orphan Biovitrum AB (publ)	Ipsen SA
20	Perrigo Company PLC	Perrigo Company PLC	Grifols SA	Grifols SA	Krka dd Novo Mesto
21	Orion Oyj	Ipsen SA	Laboratorios Farmaceuticos ROVI SA	Laboratorios Farmaceuticos ROVI SA	Laboratorios Farmaceuticos ROVI SA
22	Ipsen SA	Camurus AB	Perrigo Company PLC	Perrigo Company PLC	Perrigo Company PLC
23	Laboratorios Farmaceuticos ROVI SA	Orion Oyj	ALK-Abello A/S	ALK-Abello A/S	Orion Oyj
24	Camurus AB	Biogaia AB	Orion Oyj	Orion Oyj	ALK-Abello A/S
25	ALK-Abello A/S	Laboratorios Farmaceuticos ROVI SA	Camurus AB	Camurus AB	Camurus AB
26	Biogaia AB	ALK-Abello A/S	Fagron NV	Fagron NV	Biogaia AB
27	Fagron NV	Fagron NV	Biogaia AB	Biogaia AB	Fagron NV
28	H Lundbeck A/S	H Lundbeck A/S	H Lundbeck A/S	H Lundbeck A/S	H Lundbeck A/S
29	Almirall SA	Biotest AG	Bavarian Nordic A/S	Bavarian Nordic A/S	Almirall SA
30	Biotest AG	Virbac SA	Biotest AG	Almirall SA	Biotest SA
31	Orexo AB	Almirall SA	Almirall SA	Biotest AG	Virbac SA
32	Faes Farma SA	Orexo AB	Virbac SA	Virbac SA	Faes Farma SA
33	Virbac SA	Neuca SA	Faes Farma SA	Faes Farma SA	Biotest AG
34	Bavarian Nordic A/S	Faes Farma SA	Orexo AB	Boiron SA	Orexo AB
35	Boiron SA	Bavarian Nordic A/S	Boiron SA	Orexo AB	Bavarian Nordic A/S
36	Neuca SA	Boiron SA	Neuca SA	Neuca SA	Neuca SA
37	Pharming Group NV	Pharming Group NV	Pharming Group NV	Pharming Group NV	Pharming Group NV
38	Probi AB	Dermapharm Holding SE	Probi AB	Probi AB	Probi AB
39	Mithra Pharmaceuticals SA	Probi AB	Mithra Pharmaceuticals SA	Mithra Pharmaceuticals SA	Mithra Pharmaceuticals SA
40	Dermapharm Holding SE	Nox Group PLC	Animalcare Group plc	Animalcare Group plc	Dermapharm Holding SE
41	Nox Group PLC	Mithra Pharmaceuticals SA	Nox Group PLC	Nox Group PLC	Alliance Pharma PLC
42	Uniphar PLC	Alliance Pharma PLC	Uniphar PLC	Callidtas Therapeutics AB	Uniphar PLC
43	Alliance Pharma PLC	Uniphar PLC	Callidtas Therapeutics AB	Uniphar PLC	Nox Group PLC
44	Animalcare Group plc	Pharmanutra SpA	Alliance Pharma PLC	Alliance Pharma PLC	Animalcare Group plc
45	Jazz Pharmaceuticals PLC	Jazz Pharmaceuticals PLC	Dermapharm Holding SE	Dermapharm Holding SE	Jazz Pharmaceuticals PLC
46	Pharmanutra SpA	Animalcare Group plc	Vivesto AB	Vivesto AB	Pharmanutra SpA
47	Callidtas Therapeutics AB	Cosmo Pharmaceuticals NV	Jazz Pharmaceuticals PLC	Jazz Pharmaceuticals PLC	Callidtas Therapeutics AB
48	Vivesto AB	Callidtas Therapeutics AB	Dbv Technologies SA	Dbv Technologies SA	Vivesto AB
49	Dbv Technologies SA	PolyPeptide Group AG	Pharmanutra SpA	Pharmanutra SpA	Cosmo Pharmaceuticals NV
50	Cosmo Pharmaceuticals NV	Vivesto AB	Cosmo Pharmaceuticals NV	Cosmo Pharmaceuticals NV	Dbv Technologies SA
51	Bonesupport Holding AB	Bonesupport Holding AB	Bonesupport Holding AB	Bonesupport Holding AB	Bonesupport Holding AB
52	PolyPeptide Group AG	Dbv Technologies SA	Swedencare AB (publ)	Swedencare AB (publ)	PolyPeptide Group AG
53	Swedencare AB (publ)	Swedencare AB (publ)	PolyPeptide Group AG	PolyPeptide Group AG	Swedencare AB (publ)
54	Enzymatica AB (publ)	Enzymatica AB (publ)	ECO Animal Health Group PLC	ECO Animal Health Group PLC	Enzymatica AB (publ)
55	Spesis AG	Spesis AG	Spesis AG	Spesis AG	Spesis AG
56	Santhera Pharmaceuticals Holding AG	AB Science SA	Enzymatica AB (publ)	Enzymatica AB (publ)	AB Science SA
57	ECO Animal Health Group PLC	InDex Pharmaceuticals Holding AB	Santhera Pharmaceuticals Holding AG	Santhera Pharmaceuticals Holding AG	ECO Animal Health Group PLC
58	AB Science SA	Infant Bacterial Therapeutics AB	AB Science SA	AB Science SA	InDex Pharmaceuticals Holding AB
59	Nevron Pharmaceuticals SpA	ECO Animal Health Group PLC	Nevron Pharmaceuticals SpA	Nevron Pharmaceuticals SpA	Santhera Pharmaceuticals Holding AG
60	InDex Pharmaceuticals Holding AB	Nevron Pharmaceuticals SpA	InDex Pharmaceuticals Holding AB	InDex Pharmaceuticals Holding AB	Nevron Pharmaceuticals SpA
61	Infant Bacterial Therapeutics AB	Santhera Pharmaceuticals Holding AG	Infant Bacterial Therapeutics AB	Infant Bacterial Therapeutics AB	Infant Bacterial Therapeutics AB
62	Cyxone AB	Cyxone AB	Cyxone AB	Cyxone AB	Cyxone AB
63	Dorvkon Ls Holding AG	Dorvkon Ls Holding AG	Dorvkon Ls Holding AG	Dorvkon Ls Holding AG	Dorvkon Ls Holding AG

Figure 9. Ranking of Pharmaceutical Sector Companies.

Looking at the four rankings obtained, we notice that TOPSIS and VIKOR turn out to be almost completely similar to each other, as do SIR and PROMETHEE; all four, however, when compared with the LSEG ranking, appear very similar.

Establishing among these which method is the best in this context is very difficult, partly because, despite their specific characteristics that differentiate them, they are all valid tools for the ranking process: TOPSIS bases its ranking by identifying and starting with the alternative that has the least distance from the ideal solution and the greatest distance from the anti-ideal solution; VIKOR, despite basing its fundamentals on TOPSIS, differs from it in that it aims for a solution closer to the ideal solution, but recognizing that there might be a trade-off that better balances the criteria; PROMETHEE, as well as SIR, considered as an extension of the former, do not require an ideal reference solution, but are based on direct comparisons between alternatives: the former ranks alternatives by establishing a preference function for each criterion describing how much one alternative is preferred over another; the latter compares and evaluates alternatives in pairs to determine how “superior” or “inferior” it is in the comparison.

Conclusions

This paper investigated the application of multi-criteria analysis (MCDA) methods in the context of assessing ESG (Environmental, Social, Governance) criteria for European companies. The increasing relevance of sustainability factors, combined with the need for decision-making tools capable of dealing with complex and multi-dimensional data, makes the adoption of such methodologies an indispensable solution to address contemporary challenges related to environmental, social and governance sustainability. In the course of the paper, a comprehensive analysis of the main multicriteria decision-making methods, including TOPSIS, VIKOR, PROMETHEE and SIR, was conducted, highlighting their methodological structure, operational peculiarities and fields of application, and the different normalisation techniques such as vector normalisation, linear normalisation, and row/column maximum normalisation. Through the implementation of some of these tools, supported by the use of Python to automate the calculations and manage the large dataset, it was possible to verify how each method contributes differently to solving complex decision problems, offering results that differ according to the specific assumptions and normalization techniques used, concluding that it is difficult to decree which method is the best. The case study applied to 2412 European companies, for which data provided by the London Stock Exchange Group (LSEG) were analyzed, demonstrated the effectiveness of MCDA methods in ranking companies according to ESG criteria. Normalisation techniques, necessary to make variables with different scales comparable, played a central role in the decision-making process, allowing for a homogeneous evaluation of alternatives. In the actual analysis, the use of vector normalisation was chosen for several reasons, such as greater robustness, preservation of proportions, and applicability to datasets with many alternatives, which in this case makes it more appropriate than the others mentioned. In addition, the integration of ESG components allowed for a more accurate capture of each company's sustainability potential and risks, providing investors and stakeholders with a robust and transparent decision-making tool. The findings highlight how MCDA methodologies can support strategic decisions and sustainable investments, as well as provide a solid foundation for the development of future decision-making models, in a context where sustainability is becoming increasingly central to global agendas. The systematic and rigorous approach used in this study can be further

developed and extended to other sectors, enabling greater adaptability and applicability of MCDA tools to new challenges and decision-making contexts. In conclusion, the work demonstrated not only the effectiveness of using multi-criteria methods for ESG ratings, but also highlighted how these tools can provide a benchmark for more complex analyses in the field of sustainability. The adoption of these methods can enhance the decision-making capabilities of companies, governments, and investors, enabling a more accurate and informed assessment of strategic alternatives, always with a view to balancing economic, social, and environmental performance.

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

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Not applicable.

Code availability
Not applicable.