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Article

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Suggested Citation: Avram, Alexandru et al. (2025) : Sustainability reporting in the EU-27: The impact of national ESG ecosystems and organizational implications, Amfiteatru Economic, ISSN 2247-9104, The Bucharest University of Economic Studies, Bucharest, Vol. 27, Iss. 70, pp. 957-972, <https://doi.org/10.24818/EA/2025/70/957>

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SUSTAINABILITY REPORTING IN THE EU-27: THE IMPACT OF NATIONAL ESG ECOSYSTEMS AND ORGANIZATIONAL IMPLICATIONS

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Please cite this article as:

Avram, A., Lungu, G.M., Avram, C.D., Popescu, L., Tobă, D. and Ciurea, I.C., 2025. Sustainability Reporting in the EU-27: The Impact of National ESG Ecosystems and Organizational Implications. *Amfiteatru Economic*, 27(70), pp. 957-972.

DOI: <https://doi.org/10.24818/EA/2025/70/957>

Article History

Received: 29 March 2025

Revised: 6 May 2025

Accepted: 8 June 2025

Abstract

Sustainability reporting is a vital element that enables stakeholders to discern how companies comply with social, environmental, and governance regulations while assessing sustainable development. This study examines the national context that influences corporate sustainability reporting, emphasising the interplay between macrolevel ESG economic conditions and firm-level disclosures mandated by frameworks such as the Corporate Sustainability Reporting Directive (CSRD). While previous studies focused on organisational and concept-level analysis, the originality of this study lies in the direct evaluation of national ESG-economic ecosystems on the preparedness of EU member states for sustainability reporting under the new directive. A macroeconomic analysis of the EU-27 member states was performed using key ESG and economic indicators, with the principal component analysis generating a composite index of national performance. Additionally, the clustering of K-means revealed different regional profiles that reflect differences in ESG economic metrics. These findings have important implications, as countries with stronger macro indicators encourage environments that facilitate the adoption of advanced reporting methods, while countries facing economic and institutional challenges may require targeted interventions to improve transparency and compliance. This approach provides valuable information for policymakers and investors, emphasising the systemic links between national conditions and effective sustainability reporting at the organisational level.

Keywords: sustainability reporting, ESG, principal component analysis, K-means clustering, decision-making process.

JEL Classification: D83, M14, M48, Q58

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Introduction

Sustainability is a major trend in modern business. It motivates firms to use structured plans to look at their environmental, social, and governance (ESG) goals (Nițu, 2024). As more businesses adopt this view, more scholars focus on the principles of green and fair development, especially since not everyone benefits from the growth of the economy (Ibourk and Raoui, 2023). And the rules of sustainability are not just for the business field. According to Dima and Ghinea (2016), they also belong in schools by looking at leadership trends and making the school more competitive. All of this shows how widely sustainability plans are used.

Reports have long since shown a rather unstructured view of firm ESG performance. A very rapid change has recently taken that practice to what is now known as sustainability reporting, the structured communication of the company's ESG performance and commitment regarding sustainable development to the broader society. These would include detailed policies on the environment, emissions and wastes, human resources, and general social policies, such as diversity, equity, and inclusion. In Romania, according to OMFP 85/2024, the report indicates that the sustainability aspect is strategically vital for market competitiveness and development and, therefore, can be used to restate the development depicted by the firm. Normally, these are prepared in response to some internationally recognised standard, such as that of the Global Reporting Initiative (GRI). Sustainability reports were founded in response to greater transparency and awareness of stakeholders as a foundation for corporate social responsibility activities to create long-term value. Reporting under CSR would thus be directed at the former of the two, responsible for creating new value systems in enterprises, since reporting is the foundation of all the CSR activities set in enterprises introduced by these new value systems, as stated in the Paris Agreement of December 12, 2015.

Recent legislative changes have led to a major transformation of the way companies report their sustainability initiatives. The new Corporate Sustainability Reporting Directive (CSRD), which entered into force in January 2023, extends and details the current requirements based on the previous non-financial reporting. Through CSRD, reporting becomes broader and more standardised, emphasising not only ESG performance and risk exposure, but also sustainability integration into the business strategy. At the same time, the directive introduces the “double materiality” principle, asking companies to describe both the way sustainability aspects affect their activity and the impact their operations have on the environment and society at large. With the CSRD entry information force, the new global standards IFRS S1 (General Requirements for Sustainability Reporting) and IFRS S2 (Climate Disclosures) were also launched. These frameworks are designed to guide companies in presenting material sustainability risks and opportunities from the perspective of investors and other stakeholders. In Romania, these regulations are transposed through OMFP 85/2024, which clearly establishes the guidelines for the integration of ESG data into the basic corporate reporting.

Despite this progress, many organisations are facing difficulties, either due to the complexities of the new standards, the lack of adequate internal competencies, or the lack of access to ESG data in a standardised format. Furthermore, variations in reporting practices and the motivations behind them from one jurisdiction to another hinder the genuine comparability of information. To overcome these obstacles, it is essential that companies, regulators, and all interested parties collaborate to apply uniform requirements at the EU level.

Based on these realities and challenges, the main objective of this study is to evaluate how the national ESG-economic contexts of the EU-27 member states are prepared to effectively adopt and implement the CSRD requirements. To this end, we will construct a composite index of national preparedness for sustainability reporting using Principal Component Analysis (PCA), and we will identify regional ESG-economic performance patterns through K-means clustering, so as to provide practical recommendations to policymakers for the coherent and efficient implementation of the new directive.

1. Review of the specialised literature

Sustainability reporting has gained prominence within the converging forces of global institutions and academic research. The International Integrated Reporting Council (IIRC) brings together regulators, investors, companies, standard-setting bodies, accounting professionals, and NGOs in a global coalition aimed at developing the integrated report, which is a concise corporate document oriented toward users' needs (IIRC, 2013). Through this initiative, all key players, such as standard-setters, investors, and other stakeholders, collaborate to harmonise financial and nonfinancial information with sustainability objectives, thus ensuring clear communication of long-term value.

Integrated sustainability in reporting has already been shown to improve transparency, accountability, and stakeholder trust, which is why integrated reports are increasingly preferred. Research indicates that these reports, by offering a comprehensive view of corporate performance, significantly improve transparency and accountability (Friedman and Miles, 2002; Tihanyi, Graffin and George, 2014; Ioannou and Serafeim, 2015), optimise long-term strategic and operational decision making of companies (Ioannou and Serafeim, 2015; Waddock, Bodwell and Leigh, 2017), and strengthen organisational reputation (Epstein and Roy, 2004). Additionally, they facilitate interdisciplinary collaboration (Hahn and Kühnen, 2013), increase investor engagement (Ionescu et al., 2019), help manage complexity (Dănescu and Matei, 2020), and support talent attraction and retention (Zbucnea et al., 2019), thus conferring strategic value on corporate governance. As firms combine financial reporting with ESG disclosures (Clayton, Rogerson and Rampedi, 2015; Camilleri, 2018), the alignment of strategy, financial performance, and ESG outcomes has driven the adoption of integrated reporting (Stubbs and Higgins, 2018). Scholars such as Thejo (2017), Herzig and Schaltegger (2011) and Lozano (2015) emphasise that sustainability reporting not only promotes transparency, but also enhances public image credibility. To harmonise various standards and meet investor needs, bodies such as the Sustainability Accounting Standards Board (SASB) and the International Sustainability Standards Board (ISSB), established in 2021, have emerged. The adoption in 2022 of the new Corporate Sustainability Reporting Directive (CSRD) and the development of European Sustainability Reporting Standards (ESRS) mark a transition toward a unified, comprehensive framework designed to increase the transparency and comparability of sustainability reporting across the entire EU.

Recent academic literature stresses substantial disparities in sustainability and reporting practices in European countries. Quantitative analyses of the Sustainable Development Goals (SDGs) confirm that Europe advances heterogeneously: Nordic countries (such as Sweden) stand out positively, while others lag far behind (Anselmi et al., 2023). Studies focused on ESG indicators show similar results: Nordic countries achieve top national ESG scores, as opposed to economies in southern and eastern Europe, which consistently rank at the bottom

(Pineau et al., 2022; Copcă et al., 2024; Cojocaru et al., 2025). In fact, some western and northern European states have advanced institutional ecosystems for ESG reporting, while others are only in the early stages of developing a sustainable reporting framework (Singhania and Saini, 2022). The EU policy approach implicitly acknowledges these disparities: European authorities emphasise the combination of stringent rules with flexibility and the participation of local stakeholders. In the context of the new reporting requirements, a multi-actor model that includes dialogue with national authorities and reporting entities is deemed essential to ensure effective implementation of sustainability standards (Anselmi et al., 2023).

Most research to date has focused either at the micro level (companies and their reporting practices), on macro indicators of overall sustainability (for example, composite sustainable development indices), or on conceptual notions. Unlike these approaches, the present study investigates the relationship between national ESG economic ecosystems and the readiness of the EU-27 states to implement the CSRD, a perspective that has been relatively unaddressed in the current literature. Our contribution lies in the integration of environmental, social, governance, and economic development factors into a national ESG economic composite index, constructed using Principal Component Analysis (PCA). We then apply clustering algorithms (K-means) to group the EU-27 states into homogeneous regional profiles based on their ESG economic characteristics. This data-driven methodological approach allows the identification of systemic patterns of institutional capacity and national preparedness.

2. Research Methodology

A macroeconomic analysis was conducted in the 27 member states of the EU (EU-27) with a set of environmental indicators (environmental performance index, CO2 emissions per capita, overall share of energy from renewable sources, municipal waste recycling rate, circular material use rate), social indicators (human development index, digital society and economy index, people at risk of poverty or social exclusion, employment rate, gender employment gap, years of healthy life at birth), governance indicators (corruption perception index, individuals who used a website or an app of a public authority in the last 12 months, rule of law score, political stability, government effectiveness score), and economic indicators (competitive sustainability index, GDP per capita in PPS, share of government budget allocations for research and development in total general government expenditure, government consolidated gross debt, environmental tax revenues). These data were drawn from public databases such as Eurostat, the European Commission, the World Bank, Yale University, Cambridge University, Our World in Data, and the United Nations. For each indicator, the most recently published value was used (predominantly from 2023, with a small percentage from 2022 and 2024). This approach maximises data currency, and a temporal deviation of up to one year does not significantly affect the comparability between states.

The indicators were used to perform the Principal Component Analysis (PCA), which produced a single-dimensional index that captured the economic performance of each country on the ESG. K-means clustering was then applied to reveal groups of countries with similar profiles, thereby highlighting regional patterns and providing a broader comparative framework for understanding ESG dynamics in the EU. Importantly, the values resulting from both PCA and cluster analysis do not only represent composite ESG and economic performance scores; they also reflect each country's ability to nurture an institutional and

regulatory environment conducive to sustainability reporting at the organisational level. A complete institutional framework, high standards of governance, and major investments in technology and digitisation are important factors that influence the ease with which companies can adopt and implement sustainability reporting standards, such as IFRS S1, IFRS S2 and the CSRD. In this context, macro-level indicators serve as a proxy for the readiness of individual organisations within each country to meet the detailed disclosure and transparency requirements imposed by the new European regulations. For example, higher scores in governance and digital infrastructure can reduce the cost and complexity of implementing these standards, whereas countries with weaker institutional frameworks may require additional capacity building to align with IFRS best practices. This approach helps bridge the gap between national economic conditions on ESG and corporate-level reporting practices, offering valuable insights for policy makers and stakeholders who want to improve the overall quality and comparability of sustainability reports across the EU.

First, all variables were rescaled so that higher numerical values consistently represented more favourable outcomes. The principal component analysis was then conducted on the set of variables. For each EU-27 country, the first three main components were extracted and weighted according to their respective shares of explained variance, which cumulatively amounts to approximately 0.68, as seen in Table no. 1.

Table no. 1. Principal Component Variance and Normalised Weights

Principal Component	Raw Variance Explained	Normalised Weight
PC1	0.46	0.68
PC2	0.12	0.17
PC3	0.10	0.14
Total	0.68	1.00

$$w_k = \frac{\lambda_k}{\lambda_1 + \lambda_2 + \lambda_3} \text{ for } k = 1, 2, 3 \quad (1)$$

where:

λ_k = eigenvalue corresponding to the k th principal component

w_k = weight assigned to the k th principal component

These weighted components were then summed to construct a single composite index. This index, with higher values indicating better overall performance, facilitates the classification of countries and allows further stratification into quantiles, deciles, or percentiles.

$$I_i = w_1 PC_{i1} + w_2 PC_{i2} + w_3 PC_{i3} \quad (2)$$

where:

PC_{ik} = score for country i on the k th principal component

I_i = composite index for country i

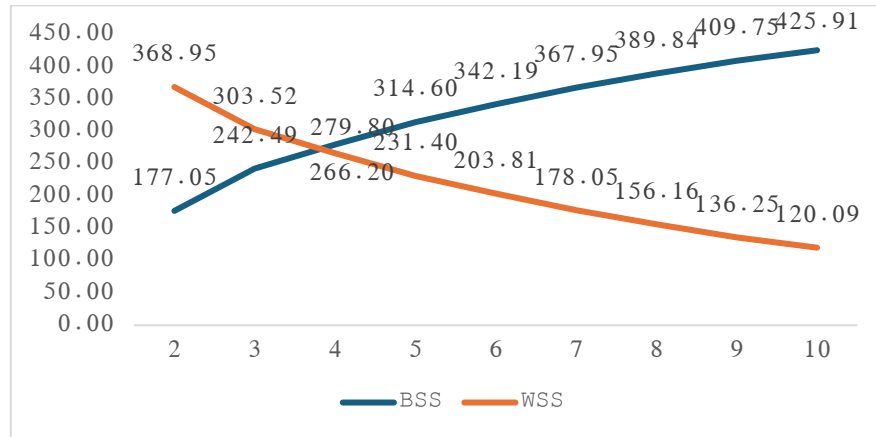


Figure no. 1. Between-Cluster and Within-Cluster Sum of Squares as a Function of k

For the second analysis, k-means clustering was applied by varying the number of clusters N from two to ten, as seen in Table no. 2.

Table no. 2. K-Means Clustering Results by Number of Clusters

No. of clusters	BSS	WSS	Proportion BSS/(BSS+WSS)
2	177.05	368.95	0.32
3	242.49	303.52	0.44
4	279.80	266.20	0.51
5	314.60	231.40	0.58
6	342.19	203.81	0.63
7	367.95	178.05	0.67
8	389.84	156.16	0.71
9	409.75	136.25	0.75
10	425.91	120.09	0.78

For each N, the between-cluster sum of squares (BSS), within-cluster sum of squares (WSS), and the proportion of explained variance were calculated. We notice that as N increases, BSS increases due to the more refined partition of the data, whereas WSS declines because the clusters become increasingly compact (Figure no. 1). The proportion of explained variance grows from approximately 32% in two clusters to around 78% in ten clusters, meaning that additional clusters account for progressively more of the total variation. However, given the fact that our analysis is limited to the EU-27 countries, for interpretability, we shall choose at most six clusters, to avoid the overfitting that would result from too many clusters and the fragmentation of the countries.

3. Results and debates

The selection of the variables included was guided by the objective of capturing a comprehensive and multidimensional view of the structural capacity of each country to support the reporting of ESG. Environmental indicators (e.g., CO₂ emissions, renewable energy share, recycling rate) reflect sustainability performance, while socioeconomic and

institutional indicators (e.g., HDI, government effectiveness, poverty risk, rule of law) provide information on governance quality and social inclusion. The inclusion of digitalisation metrics, such as the DESI index and e-government usage, directly responds to the increasing reliance on digital infrastructure in sustainability reporting. Economic indicators, such as GDP per capita and environmental tax revenues, were chosen to account for financial capacity and commitment to green transitions. Together, these variables align with international frameworks for sustainable development and integrated reporting (GRI, CSRD, IFRS S1/S2) and allow for a comparative spatial analysis of ESG readiness in EU member states.

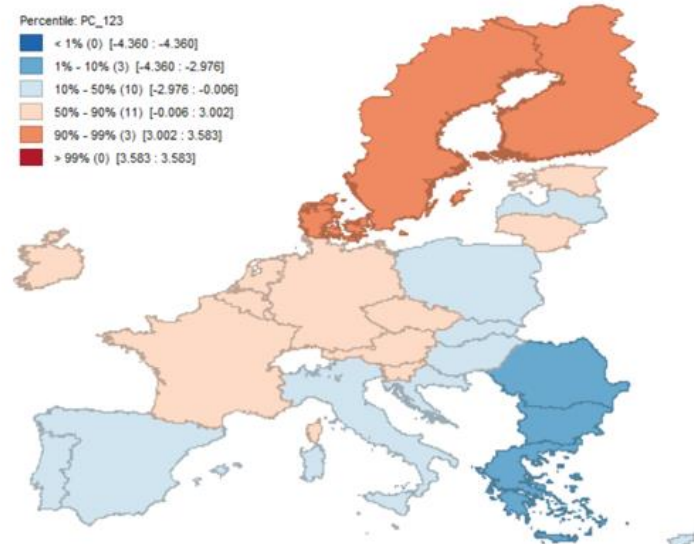


Figure no. 4. Percentile distribution of the principal component score

Figure 4 graphically summarises the scores of the main components derived from the PCA analysis, which express the distribution of the ESG economic performances of the EU countries in percentiles. This representation allows for the identification of significant differences between nations and the link between the scores received and the level of willingness to implement consistent sustainable reporting policies.

Although sustainability reporting occurs at the organisational level, it is deeply influenced by national policies, digital infrastructure, and governance quality. These macrolevel factors not only shape the overall business climate, but also determine the capacity of companies to adopt and effectively implement advanced sustainability reporting frameworks. To capture the status and performance of a country in terms of ESG and economic indicators and, by extension, its readiness for sustainability reporting, we created a single index using Principal Component Analysis (PCA), which allows us to rank the EU-27 countries on a unidimensional scale. A higher index value indicates better ESG and economic performance, which in turn suggests a stronger institutional and regulatory environment that supports detailed sustainability disclosures required by standards such as CSRD. Figure 4 shows the percentile distribution of the principal component scores, ranging from -4.360 to +3.583. Because PCA involves standardising variables and then projecting them onto orthogonal axes of maximal variance, the resulting scores can span both negative and positive values. The countries with the highest scores (+3.002 to +3.583) can be found in Northern Europe

(Denmark, Sweden, and Finland). These countries exhibit strong governance, advanced digital infrastructure, and strong environmental policies. This combination creates a favourable environment for companies to implement effective sustainability reporting practices. In the next highest percentile, which boasts the most countries, with scores ranging from -0.006 to +3.002, we have Western European (Ireland, France, Luxembourg, the Netherlands, Belgium, Germany, Austria), 2/3 of the Baltics (Estonia, Lithuania) and certain Central European (the Czech Republic, Slovenia) countries. These countries also have a relatively conducive environment for reliable ESG disclosures.

Conversely, the Southern European countries (Italy, Spain, Portugal, Malta, Cyprus) together with the rest of Central Europe ones (Poland, Slovakia, Hungary), Croatia (Southeast), and Latvia (Baltics) cluster towards the lower percentiles (scores between -2.976 to -0.006), whereas eastern Europe (Romania, Bulgaria) and Greece (Southeast) show the lowest possible scores (-4.360 to -2.976).). The underlying implication of these scores is that countries with higher principal component scores, found in Northern and Western Europe, are better positioned to implement effective sustainability and ESG reporting due to factors such as stronger governance, well-established regulatory frameworks, higher levels of interest, and investment in environmental actions, to name a few. Countries with lower scores, compared, often in southern and eastern Europe, face greater challenges in developing consistent and transparent reporting practices, given their weaker institutional capacity and limited economic resources, which is why a targeted capacity-building approach must be adopted to help these countries align their sustainability reporting frameworks with established best practices.

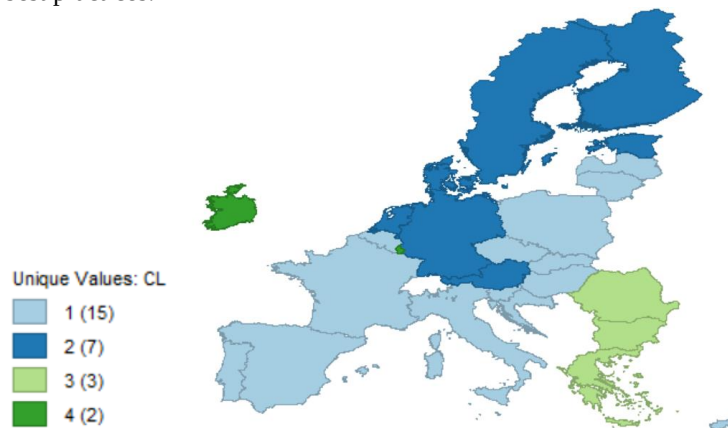


Figure no. 5. K-Means Clustering of EU-27 Countries by ESG and Economic Indicators (4 Clusters)

To deepen our study, we ran a K-means clustering analysis so as to capture also the similarities between the countries in the chosen dimensions, not just how they rank among each other. For $n = 4$ (Figure no. 5, Table no. 4), the largest cluster is the first one, boasting 15 out of the total 27 European countries. Countries in this group show moderate to strong performance in most indicators, combining reasonably high index scores (environmental performance index, competitive sustainability index) with a middle-range GDP per capita. Besides this, they exhibit moderately favourable governance measures (corruption perceptions, rule of law), but are not at the very top. These results suggest that the cluster 1 nations have established a solid

foundation for both ESG and economic growth, which is key to having an environment that supports sustainability reporting at the company level. In particular, the macro-level readiness evidenced by this cluster underpins corporate compliance with emerging requirements such as those outlined in the Corporate Sustainability Reporting Directive (CSRD). Companies operating within these nations are likely to benefit from clearer regulatory frameworks, enhanced digital infrastructure, and improved institutional capacities – all of which facilitate more effective and transparent ESG disclosures.

Table no. 4. Cluster centres by variable for n=4

Variable	C1	C2	C3	C4
Environmental performance index	62.97	71.11	60.27	70.45
CO2 emissions per capita (tonnes per person)	5.08	5.87	4.77	8.55
Overall share of energy from renewable sources (% of gross final energy consumption)	23.30	40.33	24.53	14.81
Recycling rate of municipal waste (%)	40.81	50.24	18.07	48.20
Circular material use rate (%)	10.35	14.04	3.80	6.25
Competitive Sustainability Index	47.76	65.75	31.88	60.65
GDP per capita in PPS	88.93	113.29	70.33	225.00
Share of GBARD in total general government expenditure (%)	1.03	1.80	0.70	1.12
Government consolidated gross debt expressed as % of GDP	73.73	49.86	78.57	34.40
Environmental tax revenues expressed as % of GDP	2.16	2.21	3.24	1.12
Human Development Index (HDI)	0.90	0.94	0.84	0.94
Digital Society and Economy Index (DESI)	50.26	62.23	35.73	60.79
Persons at risk of poverty or social exclusion (%)	19.58	18.73	29.37	20.30
Employment rate (% of people aged 20 to 64)	76.27	80.64	70.77	76.95
Gender employment gap (% of total population aged 20 to 64)	8.83	5.17	15.40	8.35
Healthy life years at birth	62.51	60.01	64.23	63.10
Corruptions Perceptions Index	55.53	80.29	46.00	79.00
Individuals who used a website or an app of a public authority in the last 12 months (%)	73.89	86.77	41.12	88.19
Rule of law score	0.83	1.69	0.21	1.69
Political stability	0.61	0.71	0.32	0.98
Government effectiveness score	0.75	1.54	0.04	1.75

The second cluster, encompassing seven countries (Sweden, Finland, Denmark, Estonia, the Netherlands, Germany, Austria), has the best scores overall in nearly every domain: almost double the share of energy from renewable sources compared to their Cluster 1 counterparts, the lowest number of persons at risk of poverty or social exclusion, the lowest gender employment gap, the highest recycling rates and circular material use, the lowest perceived corruption, and the strongest rule of law. These numbers indicate mature environmental policies and effective public administration, which correlate with greater transparency and trust, the key to adopting CSRD. Similarly, its advanced digital uptake (evidenced by high DESI scores) streamlines data collection and reporting processes at the corporate level, likely resulting in smoother adaptation to the new sustainability directives. The countries in this group are clear frontrunners in ESG implementation and economic performance. They can serve as role models for best-practice policy, offering information on how strong governance, high investment in innovation, and well-funded sustainability initiatives can reinforce each

other. Consequently, companies operating in these countries are likely to experience fewer hurdles in achieving detailed and reliable sustainability disclosures, thus attracting more sustainable investment and maintaining leadership in the transition toward a low-carbon, high-tech economy.

Compared to clusters 1 and 2, cluster 3 (Romania, Bulgaria, Greece) is marked by the lowest scores in almost all dimensions, apart from: the share of energy from renewable sources, where it actually scores the second highest amongst all, CO₂ emissions per capita, which, while good for the environment, showcases weaker economies, and, perhaps the most surprising of them all, the healthy life years at birth, where it scores highest among the clusters, in spite of having the worst scores among all other social-related indicators. The countries in this group face the most obstacles in terms of building institutional capacity and promoting economic growth, which is why policy interventions in the form of strengthening regulatory frameworks, investing in technological infrastructure, and improving social support systems are mission critical. External assistance, whether from EU cohesion funds or targeted capacity building programmes, is necessary not only to help these nations converge with their higher-performing peers, but also to enhance the corporate reporting environment, enabling local companies to overcome informational and operational barriers in sustainability reporting.

Cluster 4 (Ireland, Luxembourg) is somewhat of an outlier, characterised by the highest GDP per capita amongst all clusters (almost double that of cluster 2), coupled with strong governance scores and good digital adoption. However, its sustainability metrics are seriously lacking, highlighted by the highest CO₂ emissions per capita, the lowest share of energy from renewable sources, and the second lowest circular material use rate. These factors indicate some potential trade-offs between economic intensity and green transitions. With a shift in policy priorities and a more focused drive toward sustainable practices, these countries - and the companies within them - are well equipped to rapidly align with CSRD and other emerging sustainability reporting standards, thereby bridging the current gap between economic prowess and environmental performance.

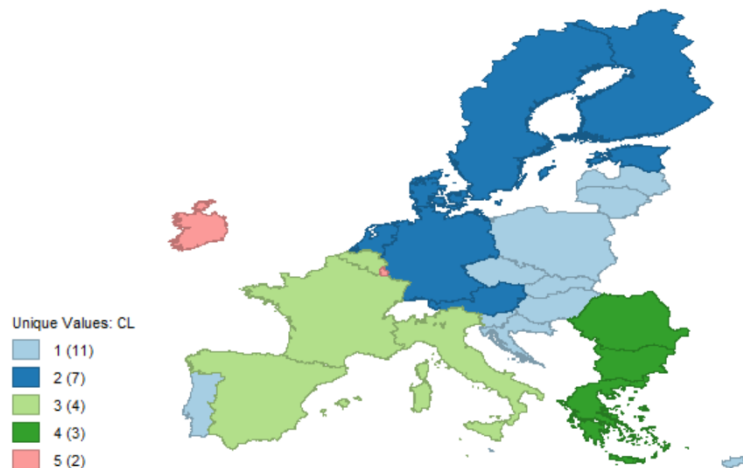


Figure no. 6. K-Means Clustering of EU-27 Countries by ESG and Economic Indicators (5 Clusters)

For the five-cluster analysis (Figure no. 6, Table no. 5), we notice that there are three clusters from the previous analysis that remained the same, namely Cluster 2, Cluster 4 (former cluster 3), and Cluster 5 (former cluster 4). The countries that were in the larger “middle” cluster (former Cluster 1 for n=4) have now split between Cluster 1, still encompassing the largest number of countries, and the newly created Cluster 3 (Spain, France, Belgium, Italy).

Table no. 5. Cluster centres by variable for n=5

Variable	C1	C2	C3	C4	C5
Environmental performance index	62.40	71.11	64.53	60.27	70.45
CO2 emissions per capita (tonnes per person)	5.01	5.87	5.28	4.77	8.55
Overall share of energy from renewable sources (% of gross final energy consumption)	24.36	40.33	20.37	24.53	14.81
Recycling rate of municipal waste (%)	38.19	50.24	48.03	18.07	48.20
Circular material use rate (%)	8.06	14.04	16.65	3.80	6.25
Competitive Sustainability Index	45.90	65.75	52.87	31.88	60.65
GDP per capita in PPS	84.36	113.29	101.50	70.33	225.00
Share of GBARD in total general government expenditure (%)	0.97	1.80	1.21	0.70	1.12
Government consolidated gross debt expressed as % of GDP	59.36	49.86	113.23	78.57	34.40
Environmental tax revenues expressed as % of GDP	2.19	2.21	2.07	3.24	1.12
Human Development Index (HDI)	0.89	0.94	0.92	0.84	0.94
Digital Society and Economy Index (DESI)	49.11	62.23	53.42	35.73	60.79
Persons at risk of poverty or social exclusion (%)	18.67	18.73	22.08	29.37	20.30
Employment rate (% of people aged 20 to 64)	78.25	80.64	70.83	70.77	76.95
Gender employment gap (% of total population aged 20 to 64)	8.14	5.17	10.73	15.40	8.35
Healthy life years at birth	61.90	60.01	64.18	64.23	63.10
Corruptions Perceptions Index	53.36	80.29	61.50	46.00	79.00
Individuals who used a website or an app of a public authority in the last 12 months (%)	73.13	86.77	75.96	41.12	88.19
Rule of law score	0.79	1.69	0.92	0.21	1.69
Political stability	0.69	0.71	0.40	0.32	0.98
Government effectiveness score	0.71	1.54	0.89	0.04	1.75

Cluster 3 sits in mid-range positions for most indicators, performing better than the lower-scoring groups (clusters 1 and 4) on certain metrics, but not reaching the top-tier levels of the highest-performers (clusters 2 and 5). Its GDP per capita is higher than in the lower clusters but lags behind the best performing groups. Governance-related variables tend to be respectable, but do not match the highest scores seen in more advanced clusters. The environmental indicators tell the same story, though the cluster performs best of all when it comes to circular material use. In the case of social indicators, these countries perform second to worst when it comes to people at risk of social exclusion and the gender-employment gap. Perhaps the most interesting fact is that this group of countries has the highest government-consolidated gross debt out of all clusters. This high debt burden shows fiscal constraints, which can limit the countries' capacities to invest in sustainability initiatives or social support measures. Over time, managing or reducing this elevated debt becomes critical, not only for economic stability, but also to free up resources for the kinds of policy interventions needed to boost ESG performance and, by extension, enhance the environment for sustainability reporting in line with the CSRD.

For n=6 (Figure no. 7, Table no. 6) we see the clusters' further segmentation. Cluster 1 is largely unchanged, retaining many of the same countries. These nations still show moderate governance and economic scores, with middle-range sustainability indicators. Cluster 2 (Germany, the Czech Republic, Austria, Slovenia, Belgium, The Netherlands) maintains a high-scoring profile in GDP and some of the environmental indicators. However, they lag

slightly behind the newly formed Cluster 3 in some aspects, such as governance, but still rank among the leaders. Cluster 3 (Denmark, Sweden, Finland, Estonia) represents a refined split from what was previously the highest-level group. These countries are frontrunners when it comes to high index scores (highest scores among clusters for the Competitive Sustainability Index, Digital society and economy index, Environment performance index), R&D investment, social indicators, and score near the top for all governance-related variables. Cluster 4 (Ireland, Luxembourg) remains the same as the previous high-performing group. It still shows the highest GDP per capita, has strong digital adoption scores, and the highest governance scores. Certain environmental and social indicators vary, but these countries still rank near the top of the rankings.

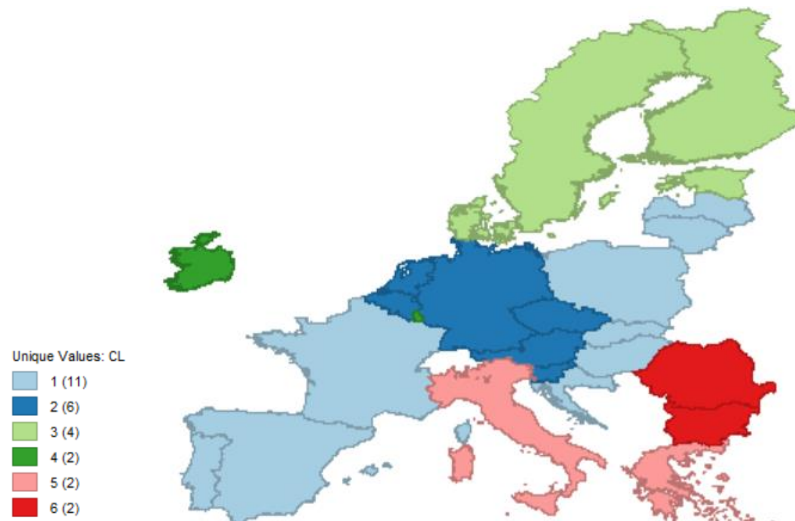


Figure no. 7. K-Means Clustering of EU-27 Countries by ESG and Economic Indicators (6 Clusters)

Cluster 5 (Italy, Greece), previously part of a larger mid-range cluster, has now split, isolating the countries with the second weakest ESG and economic scores and highest debt burdens amongst all member states. Cluster 6 (Romania, Bulgaria) is a continuation of the lowest-performing group, capturing the countries with the most significant structural and governance challenges, plus the weakest environmental and economic scores.

All in all, the unfolding of new clusters reveals more granular differences within what used to be a broad mid-tier. Policymakers could now be able to design interventions fit for these narrower profiles, focussing, for instance, on the high debt in Cluster 5 or on bridging small governance gaps in Cluster 2. In the case of investment prospects, Clusters 2, 3, and 4 are well equipped to attract sustainable investments, given their strong metrics. Cluster 5, in contrast, might need targeted EU funding or cohesion programmes to address debt and institutional issues, while Cluster 6 will likely require deeper structural reforms to exit the lowest tier.

Table no. 6. Cluster centres by variable for n=6

Variable	C1	C2	C3	C4	C5	C6
Environmental performance index	62.67	67.52	71.88	70.45	63.80	56.75
CO2 emissions per capita (tonnes per person)	4.60	6.73	5.25	8.55	5.35	4.45
Overall share of energy from renewable sources (% of gross final energy consumption)	24.68	23.04	50.62	14.81	22.43	24.16
Recycling rate of municipal waste (%)	36.20	58.35	40.58	48.20	35.30	18.45
Circular material use rate (%)	8.47	16.68	9.88	6.25	13.00	3.10
Competitive Sustainability Index	46.05	58.83	67.58	60.65	42.65	28.55
GDP per capita in PPS	85.09	111.50	106.00	225.00	83.50	71.00
Share of GBARD in total general government expenditure (%)	0.96	1.57	1.73	1.12	1.17	0.48
Government consolidated gross debt expressed as % of GDP	68.84	66.75	40.60	34.40	149.35	35.90
Environmental tax revenues expressed as % of GDP	2.10	2.20	2.23	1.12	3.33	2.80
Human Development Index (HDI)	0.89	0.93	0.94	0.94	0.90	0.82
Digital Society and Economy Index (DESI)	50.17	54.63	65.17	60.79	44.09	34.14
Persons at risk of poverty or social exclusion (%)	20.60	16.52	19.08	20.30	24.45	31.00
Employment rate (% of people aged 20 to 64)	76.95	78.63	81.00	76.95	66.85	72.45
Gender employment gap (% of the total population aged 20 to 64)	7.75	8.48	3.23	8.35	19.65	13.20
Healthy life years at birth	61.64	62.12	59.90	63.10	67.20	62.85
Corruptions Perceptions Index	54.00	67.50	85.50	79.00	51.50	44.50
Individuals who used a website or an app of a public authority in the last 12 months (%)	74.87	76.82	94.01	88.19	60.72	28.52
Rule of law score	0.78	1.40	1.73	1.69	0.30	0.22
Political stability and absence of violence/terrorism score	0.58	0.70	0.75	0.98	0.41	0.36
Government effectiveness score	0.68	1.22	1.66	1.75	0.38	0.02

The analysis aims to show the role that the macro-level ESG and economic environment across EU member states has in shaping the capacity of companies to engage in sustainability reporting under frameworks such as CSRD. Refined clustering reveals different national profiles, highlighting how differences in governance, digital infrastructure, and fiscal health can propel or hinder the quality of corporate ESG disclosures. These findings underscore the importance of tailored policy interventions, ranging from EU cohesion funding for high-debt nations to strategic governance enhancements in lower-performing clusters, to support an enabling environment for effective sustainability reporting.

Conclusions

The study's findings demonstrate that the effectiveness of sustainability reporting can never be separated from the institutional and economic context in which it operates. Macroeconomic and ESG indicators, as analysed at the level of the member states of the European Union, reflect systemic conditions that directly or indirectly shape the reporting framework applicable to companies. Therefore, in this logic, reporting ceases to be a mere technical exercise in providing information, but becomes an expression of governance capacity, digital maturity, and strategic orientation toward sustainable development objectives. Consequently, as CSRD begins to be implemented, companies in the respective countries comprising the highest performing clusters can act as role models for best practices, while those in the lowest performing clusters could benefit from targeted EU-level policies and national reforms to strengthen aspects such as governance, digital infrastructure, and environmental performance in support of robust sustainability reporting. Our findings hint at a causal interplay: as nations improve their institutional frameworks and digital infrastructures, firms benefit from clearer guidelines and a

more supportive environment for adopting advanced sustainability reporting methods, ultimately reinforcing the overall transparency and accountability of corporate disclosures. This dual focus on innovation and the underlying causal relationships ensures that efforts to improve reporting are well-founded and capable of evolving in tandem with rapidly changing regulatory and economic landscapes.

The macroeconomic analysis conducted using Principal Component Analysis (PCA) and the K-means clustering algorithm highlights noteworthy regional patterns in ESG and economic performance. By creating a composite index through PCA, the study was able to rank countries along a single-dimensional scale, providing a clear view of which nations are best positioned to implement effective sustainability and ESG reporting. The K-means clustering complemented this analysis by delineating the 27 EU Member States into distinct groups that share common ESG and economic characteristics. Thus, this scientific contribution offers a fresh perspective that enriches the previously organisation and concept-focused literature.

In practical terms, the results provide policymakers and stakeholders involved in CSRD implementation with a data-driven foundation for designing targeted policies, while also reinforcing the importance of integrating both quantitative and qualitative dimensions into sustainability reporting and strategic decision-making.

However, the study focusses exclusively on the national context of the 27 EU member states and on macroeconomic indicators of ESG, without capturing sectoral variations or the perspectives of individual companies, which limits the generalisability of the results at the microlevel. Furthermore, the cross-sectional approach provides a static view of the interactions between governance and sustainability, without reflecting the long-term effects of the policies implemented. Future research could extend the analysis over a longer time frame to capture the evolutionary dynamics of ESG economic ecosystems, compare the EU-27 with other regions to identify global patterns, and combine macro-data with firm-level case studies and interviews to detail the mechanisms by which national environments shape reporting practices.

Acknowledgements

The research study has been produced within the project funded by the European Union's NextGenerationEU instrument through Romania's National Recovery and Resilience Plan, Pillar III-C9-I8, managed by the Ministry of Research, Innovation, and Digitalisation, as part of the project titled "CauseFinder: Causality in the Era of Big Data and AI and its Applications in Innovation Management," Contract No. 760049/23.05.2023, code CF 268/29.11.2023.

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