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Mismatches Between Environmental Performance and Sustainable Investments as Signals of Misleading Green Corporate Messaging

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Abstract

This study investigates the misalignment between ESG environmental (E) scores and actual sustainable investment activities, addressing a critical gap in the literature regarding the reliability of ESG metrics. While prior research has highlighted concerns about greenwashing, few studies have systematically linked ESG ratings to EU Taxonomy-based capital expenditure (CapEx) indicators. This study aims to bridge this gap by developing a novel firm-level typology that captures discrepancies between reported environmental performance and real investment commitments. The empirical analysis is based on Bloomberg data for European firms over the 2022–2024 period and employs cluster analysis alongside non-parametric statistical testing (Kruskal–Wallis) to assess intergroup differences. The findings reveal substantial heterogeneity across firms, including cases where high ESG 'E' scores are not supported by aligned sustainable investments and instances of under-recognised investment activity. These inconsistencies suggest potential distortions in ESG signalling and indicate limitations in current rating methodologies. The study contributes to the literature by integrating ESG evaluation with EU Taxonomy metrics and proposing a refined analytical framework for detecting greenwashing risks. From a practical perspective, the results provide valuable insights for investors, regulators and policymakers seeking to enhance the credibility, comparability and transparency of sustainability disclosures.

Keywords: sustainable investments; greenwashing; environmental score; EU taxonomy; sustainability

JEL Classification: M21; M41; M48; Q56

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1. Introduction

Sustainability issues have become inseparable from companies' strategic management and investment decisions in recent years: integrating sustainability into management connotes maintaining long-term competitiveness, ensuring financial stability, and managing risk. The scientific literature typically understands sustainability as a concept encompassing environmental, social, and governance aspects that must be managed in a balanced way over the long term (Li et al., 2025; Christensen et al., 2022; Berg et al., 2022). This context makes the assessment of environmental governance relevant not only as a compliance requirement but also as a factor in competitive advantage and capital raising, because it is considered important for companies to demonstrate that the declared en-

vironmental commitments are based on real results and investments (Berg et al., 2022; Cheema-Fox et al., 2025).

Despite environmental sustainability's conceptual presence in measurement practices and the scientific literature (Berg et al., 2022; Christensen et al., 2022), the lack of a unified methodological approach to accurately measure companies' environmental management remains problematic. One strand of research relies on quantitative environmental indicators (e.g., GHG emissions, energy consumption, water consumption, amount of waste, number of pollution violations) (Dauerer, 2025; Li et al., 2025; Chardine-Baumann & Botta-Genoulaz, 2014), while another uses composite ESG ratings or indices (Kabir & Chowdhury, 2023; Vaitiekuniene et al., 2024), which includes not only quantitative results, but also qualitative disclosures and management tools.

This methodological diversity limits the comparability of results while increasing the risk that environmental progress will be measured by an overall ESG score that reflects not only environmental protection but also social and governance factors. Consequently, the problem arises that the environmental component 'E', being the most important in the context of climate change, often becomes a methodologically conditioned signal that does not necessarily accurately reflect the company's actual investment progress in environmental protection. This situation creates the preconditions for greenwashing, in which companies may partially disclose positive information, use unclear methodologies, or undertake symbolic activities that improve reputation but do not produce a proportionate reduction in real environmental impact.

The evolution of EU regulations amplifies the relevance of this issue (European Commission, 2023c). The European Sustainability Reporting Standards (ESRS) more clearly define which environmental indicators must be disclosed in sustainability reports (EFRAG, 2023). Meanwhile, the stricter framework represented by the EU Taxonomy Regulation allows for the differentiation of which economic activities are considered environmentally sustainable and provides an opportunity to quantify the cost of capital expenditure (CSD) for enterprises (European Commission, 2020; EY, 2024). The CapEx part is taxonomically aligned or 'eligible'. This means that—for the first time—there is a methodological basis not only to record the volume of 'green' investments, but also to assess their quality according to clear criteria. However, the scientific literature lacks research that directly links the ESG E score to taxonomically aligned CapEx and enables the systematic identification of discrepancies between the declared environmental profile and actual sustainable investments (Bernini & La Rosa, 2023; Janik & Ryszko, 2025).

In this context, the novelty of this work is based on the development and proposal of a classification of phenotypes that combines indicators of different natures: the environmental score as a reputational/disclosure signal, as well as the sustainable investments evaluated in the context of taxonomy, differentiating CapEx-eligible and CapEx-aligned indicators as measures of actual and regulatory-defined sustainable capital investments. Combining these dimensions forms the basis for an extended classification of corporate phenotypes, which reveals heterogeneous behavioural patterns, such as situations where a company demonstrates a high E score, but its share of taxonomically appropriate ('eligible') or aligned ('aligned') CapEx remains limited, or, conversely, where a significant proportion of investments is taxonomy-aligned but not reflected in disclosures or ESG assessments.

It is also permissible to distinguish between cases in which investments are potentially eligible but have not yet met all aligned criteria, thereby providing additional analytical depth when assessing companies' sustainability maturity. Such an approach enables the structural identification of various configurations of 'mismatch' that may be significant in the context of greenwashing risk, especially when reputational signals are not based on realistically coordinated investments. Including both eligible and aligned dimensions

enables identification not only of existing inconsistencies but also of transitional states that reflect companies' progress towards full operational alignment with the taxonomy.

Notably, this system is not applied in isolation: the paper emphasises that discrepancies between the E score and CapEx-eligible and CapEx-aligned indicators must be interpreted in light of the financial capacity of companies, since investments in environmental protection are not only a strategic choice, but also the result of financial constraints (liquidity, capital structure, debt burden, risk profile). Therefore, the analysis of phenotypes is complemented by an assessment of financial and environmental characteristics, oriented towards stakeholders' information needs and improved decision-making. In addition, the proposed phenotype framework extends signalling theory by distinguishing between sustainability signals (Environmental Score) and actual sustainable investment activity (Taxonomy-eligible and Taxonomy-aligned CapEx). It also contributes to legitimacy and stakeholder theories by providing a framework for assessing whether sustainability disclosures are supported by real investment decisions and regulatory alignment.

The objective of the thesis is to differentiate European companies based on environmental, sustainable investment, and financial-situation management indicators by identifying phenotypic structures. It sets out to achieve this by developing a classification of corporate phenotypes as an instrument for identifying greenwashing that integrates environmental, sustainable investment, and financial condition management indicators.

The thesis aims to achieve these broad goals by taking the following specific steps:

1. Examine the environmental aspect of sustainability and investments, systematising the scientific literature on the role of the environmental (E) component in the ESG context, environmental management measurement indicators, and the links between environmental investments and companies' activities.
2. Analyse the problems and main forms of greenwashing, their expression through ESG indicators, and the discrepancies between declared environmental signals and the actual actions of companies.
3. Analyse the links between financial health and environmental governance to determine how financial indicators and stakeholder pressures affect the ability of companies to invest in the environment and shape their environmental profile.
4. Form a classification of corporate phenotypes based on a combination of environmental score and sustainable investments.
5. Based on the results of an expert survey, identify the main indicators of environmental protection and financial condition.
6. Empirically evaluate statistical differences between phenotypes.

This work uses mixed research methods, with the empirical analysis based on 2022–2024 data from the Bloomberg database of European companies, integrating the ESG E score and CapEx-eligible and CapEx-aligned indicators assessed under the EU taxonomy as measures of sustainable capital investment. To identify differences in company behaviour and possible discrepancies between declared environmental signals and actual investments, cluster analysis is applied, on the basis of which company phenotypes are formed. Next, the differences in phenotypes are analysed using the non-parametric Kruskal–Wallis test, which assesses whether the clusters differ statistically significantly across the environmental and financial indicators identified in the expert survey data.

2. Literature Review

2.1. Sustainability Concepts and Sustainable Investments

Sustainable solutions are becoming an integral part of companies' daily activities, allowing them to remain competitive in the market and maintain financial stability. The scientific literature usually defines sustainability as a concept that encompasses environ-

mental, social, and governance (ESG) aspects over the long term and frequently measures it using an ESG framework (Shen et al., 2023; Christensen et al., 2022). Integrating sustainability into corporate governance not only strengthens and shapes the competitive environment of companies and their business strategies but also the principles of financial management—orienting them towards long-term stability and managing them with sustainability indicators in mind. Integrating sustainability indicators into financial management strategies helps companies not only to focus on long-term stability but also to manage risks more effectively, as research shows that the integration of sustainability and risk management increases corporate resilience, improves financial performance, and reduces financial risk (Anton et al., 2025; Cippiciani et al., 2025).

Although the scientific literature presents conflicting discourse on the interrelationships among the conceptual dimensions of sustainability—and the overall balance of ESG factors is important for the financial stability of companies—the intensification of climate change driven by certain companies' activities makes the environmental aspect particularly critical (Berg et al., 2022). Nonetheless, for Naseer et al. (2025), it is particularly important to balance development between a company's environmental work and the company's management in general to create long-term value for both the company and society in the overall global context, including through contributing to international initiatives on climate change management, such as the Paris Agreement and the EU Green Deal. Furthermore, an environmental focus highlights direct environmental impacts, such as CO_2 emissions and energy consumption, which are not always reflected in the overall context of ESG scores (Berg et al., 2022). Additionally, the overall ESG score can be skewed by social and governance factors, undermining insights into environmental behaviours (Christensen et al., 2022).

Broadly speaking, assessing companies from an environmental perspective involves evaluating how companies' activities affect the external environment and how they manage that impact. Growing societal literacy around sustainability is shaping the understanding that environmental indicators can be not only a requirement for compliance, but also a significant factor in competitiveness. Key environmental performance indicators have remained broadly similar over the past few years (Dauerer, 2025), with the most common measures of the environmental performance of companies being quantitative metrics such as greenhouse gas (GHG) emissions (CO_2 equivalent, divided into Scope 1, Scope 2 and increasingly Scope 3), energy consumption (total and per unit of production), water consumption and wastewater, waste content and recycling percentage, air pollutant emissions (e.g., SO_2, NOx, particulate matter), and the use of chemicals (Li et al., 2025; Chardine-Baumann & Botta-Genoulaz, 2014). However, another part of the literature (Vaitiekuniene et al., 2024; Kabir & Chowdhury, 2023; Saba, 2025; Bikmetova & Pirinsky, 2026) evaluates ESG indicators or ratings to measure companies' environmental management, enabling the assessment of the qualitative actions companies use to manage their environmental impact. Table 1 presents the key indicators used to measure companies' environmental management.

Table 1. Environmental Measurement Indicators.

Study	Environmental Management Indicator(s)
Drejeris and Oželienė (2019)	Qualitative information related to the reduction in the use of raw materials, the reduction in the use of energy resources, the reduction in pollution, the reduction in waste
Fu and Jacobs (2022)	Water efficiency

Table 1. *Cont.*

Study	Environmental Management Indicator(s)
Kabir and Chowdhury (2023)	ESG scores
Del Vitto et al. (2023)	ESG scores
Vaitiekuniene et al. (2024)	ESG scores
Oestreich and Tsiakas (2024)	Carbon intensity
Hristov and Searcy (2025)	ESRS E1: CO_2 emissions, E2: air and water pollution, E3: water use, E4: impact on biodiversity, E5: circularity of materials (%)
Li et al. (2025)	ESG scores
Dauerer (2025)	CO_2 emissions (tCO_2e), energy consumption (kWh), Amount of waste (tonnes), water consumption (m^3), number of environmental compliance violations (units)
Matsali et al. (2025)	ESG Scores
Al Masud et al. (2025)	Environmental performance
Zhang et al. (2025)	The environmental performance of companies is measured as the ratio of emissions taxes disclosed in annual reports to total revenues
Saba (2025)	ESG Scores
Bikmetova and Pirinsky (2026)	ESG Scores

Note. Compiled by the author from the sources presented in the table.

It is apparent that the extant literature demonstrates no uniform practice for measuring the environmental management of companies, with some authors analysing only quantitative data (e.g., Dauerer, 2025; Hristov & Searcy, 2025), and others using ESG scores or composite indices depending on the purpose of the study (Vaitiekuniene et al., 2024; Kabir & Chowdhury, 2023; Saba, 2025; Bikmetova & Pirinsky, 2026). To evaluate companies' environmental management, both qualitative and quantitative data should be analysed to ensure that all available information about their environmental governance is considered. Furthermore, it is necessary to interrogate the common practice of using a general composite ESG score—which represents sustainability more broadly—to represent an environmental criterion.

Sustainability regulation has been significantly impacted by the ESRS, which dictate which indicators must be disclosed in corporate sustainability reports (EFRAG, 2023). These indicators appear in Table 2. It should be noted, however, that disclosure of these indicators is mandatory only if the relevant topic (or subtopic) is significant for the company according to a double materiality assessment (European Commission, 2023c).

Table 2. ESRS-Based Environmental Quantitative Indicators.

ESRS Area	Quantitative Indicators
ESRS E1: Climate change	GHG emissions (1, 2, 3 and total) (tonnes CO_2 eq); GHG emission intensity (tCO_2e per unit of revenue) Energy consumption and mix of energy sources (MWh, % of renewables) GHG removals and carbon credits (tonnes of CO_2 eq) Estimated financial impact in terms of climate risks/opportunities (EUR)
ESRS E2: Pollution	Microplastic content (kg or t) Pollutant emissions to air, water, soil (tonnes) Use of 'substances of concern' (tonnes) Substances of very high concern (SVHCs) (tonnes) Estimated financial impact on pollution risks/opportunities (EUR)

Table 2. *Cont.*

ESRS Area	Quantitative Indicators
ESRS E3: Water resources	Total water consumption (m^3) Water consumption in risk areas (m^3) Reused and recycled water (m^3) Change in accumulated water (m^3) Water intensity (m^3/product unit or €) Estimated financial impact on water risks/opportunities (EUR)
ESRS E4: Biodiversity	Objects in biodiversity-sensitive areas (number and ha) Other biodiversity impact indicators (if applicable) Estimated financial impact on biodiversity risks/opportunities (EUR)
ESRS E5: Circular Economy	Resource inputs: amount of materials used (tonnes) Inputs: Use of secondary raw materials (tonnes, %) Inputs: sustainable share of biological materials (%) Resource outputs: product circularity indicators (% recyclable, durability) Resource outputs: quantity and management of waste (tonnes) Estimated financial impact on the risks and opportunities of resource use (EUR)

Note. Compiled by the author from European Commission (2023a, 2023b, 2023c) and EFRAG (2023) reports.

Based on the research reviewed in this chapter, it is apparent that the literature continues to use diverse indicators for analysis, often without accounting for sector-specific details, which may partly distort research results. Furthermore, environmental sustainability criteria often rely on a composite ESG score that reflects the broader concept of sustainability rather than environmental sustainability alone, underscoring the need to establish key environmental metrics.

As mentioned, corporate environmental governance solutions are becoming a strategic factor determining competitiveness (Abdullah et al., 2025). As such, companies allocate resources to improving these metrics. Investments in the environment typically include funding for cleaner technologies, energy efficiency, pollution-control equipment, the adoption of renewable energy, and improvements in waste management (Jiang & Ma, 2025). A study by Abdullah et al. (2025) identified a characteristic two-way relationship between environmental protection and sustainability investments: better environmental outcomes can lead to higher sustainability investments, and environmental investments themselves lead to improvements in indicators.

Elsewhere, Garad and Khalifa (2024) showed that companies improve environmental performance when implementing green innovations. That is, a company that has allocated funds to pollution-reduction technologies usually reduces pollution indicators (e.g., CO_2 or waste quantities) but also increases operational efficiency (lower energy consumption, raw material savings). For example, an analysis of Chinese companies by Li et al. (2025) showed that consistent pollution-reduction activities are usually related to prior investments in pollution control (e.g., installed filtration systems, energy-saving equipment)—thus, improved environmental performance reflects successful investments. The results of another study (Ren et al., 2023) showed that the adoption of digital technologies in industry increased peer pressure to invest in eco-innovation, thereby reducing emissions and improving environmental outcomes (specifically, investments in smart solutions helped optimise processes and reduce pollution).

Notably, Li et al. (2025) also found a statistically significant relationship between ESG scores and the volume of environmental investments when analysing ESG and environmental investments, indicating that not only quantitative metrics but also qualitative metrics determine companies' decisions regarding environmental investments. Thus, it can be said that the impact of investments on environmental management metrics is obvious—without

investments, it is difficult to expect a significant improvement in environmental indicators and other measures, and where investments are made, there is an improvement in pollution, energy and other qualitative indicators compared to companies that do not invest. Table 3 presents the main results of generalised and other authors' studies that have examined the impact of investments on environmental indicators or vice versa.

Table 3. Summary Research Considering Environmental Investments.

Study	Main Results	Environmental Investment Indicator
Berg et al. (2022)	Investors are increasingly incorporating ESG factors into their decision-making, companies with higher quality ESG information are expected to attract more capital, so better ESG indicators also lead to higher investments.	ESG investments.
Au et al. (2023)	Strong ESG performance builds long-term resilience and stakeholder trust, guides capital allocation, drives investment in sustainable development, and helps address climate change challenges.	ESG investments.
Farooq et al. (2023)	Statistical analysis reveals the negative and statistically significant impact of air pollution on companies' investments. The main logic behind negative impacts is that high levels of air pollution increase compliance costs, create financial constraints on financing investment activities, increase operational risk, etc.	General level of investment by enterprises
Wan et al. (2025)	green investments help improve companies' ESG performance.	Green investments
Luo and Zhou (2025)	The role of high-polluting and zero-polluting companies in environmental investments varies widely between high-polluting and zero-polluting companies.	Environmental investments
Li et al. (2025)	ESG outcomes have an impact on environmental investments by reducing funding constraints, strengthening internal oversight, reducing agency costs, and improving disclosure. The impact varies from industry to industry, especially for zero-polluting and technology-intensive companies.	Environmental investments

Note. Compiled by the author based on the sources presented in the table.

The studies discussed make it apparent that most researchers agree that there are links between environmental management metrics and investments in them, or vice versa, and that these links are mostly positive, regardless of the chosen investment indicator. It should be noted that when assessing investment levels in environmental initiatives, the authors often use the total expenditure on environmental protection and ESG activities. This raises the question of whether we can call all environmental activities sustainable, that is, whether they actually contribute to reducing companies' environmental impact.

The EU Taxonomy Regulation 2020/852 entered into force in July 2020 and established a common framework for determining whether companies' economic activities are environmentally sustainable (European Commission, 2020). The practical disclosure of taxonomy information to companies started from the financial year 2021, when large public-interest entities falling within the scope of the NFRD had to disclose for the first time whether their

activities are taxonomy-eligible for climate change mitigation and adaptation objectives (European Commission, 2021; KPMG, 2021). These reports were published in 2022 and did not yet require an assessment of activity alignment, only their classification under the EU Taxonomy (EY, 2024; European Union, 2024).

Regulation has gradually tightened, and since the financial year 2022 (with reports published in 2023), companies have been required to assess not only the suitability of activities but also their compliance with the technical selection criteria for the two climate objectives (European Commission, 2021; EY, 2024; Dedinienė, 2025). Over the same period, three key taxonomy indicators—turnover, cost of capital (CapEx) and OpEx—began to be systematically disclosed (European Commission, 2021). This has made it possible to quantify the share of companies' CapEx that is sustainable and compliant with the requirements of the EU Taxonomy (KPMG, 2025; EY, 2024). Regulation was further expanded in the following years.

As of the 2023 financial year, four more environmental targets have been added; from the 2024 financial year, the full application of all six environmental objectives, including both fitness and conformity assessment, has become mandatory (KPMG, 2025; PwC, 2025). Thus, it can be said that the assessment of CapEx corresponding to taxonomic activity should include the evaluation of the company's investments in fixed assets that will be used for more than one year and will generate economic benefits in the future, or investments that contribute to environmental sustainability goals. Thus, a clear definition, based on clear and strict criteria, of what constitutes sustainable economic activity increases transparency and comparability when assessing companies' investments in environmental protection.

2.2. Misleading Green Messaging in the Context of Environmental Protection

Several forms of sustainability data manipulation exist: incomplete disclosure, in which companies present only positive ESG aspects while omitting negative environmental impacts (de Amorim & de Souza, 2022); the distortion of indicators through unclear and unconfirmed calculations, common in carbon dioxide models and PPS (de Amorim & de Souza, 2022); symbolic initiatives where companies invest in green projects that have no real impact, but 'improve' the image the company presents to its stakeholders (Janik & Ryszko, 2025); and recognising that different ESG rating agencies apply different criteria, companies 'choose' the most favourable rating (Berg et al., 2022).

Researchers considering data manipulation related to sustainability have identified ESG data manipulation as a systemic problem. Dyck et al. (2023) found that companies with weak internal controls and strong pressure to improve ESG scores are more likely to disclose distorted information (Braam et al., 2016). Meanwhile, Christensen et al. (2022) recognised that differences in ESG ratings stem from differing interpretations of the data rather than actual differences, and can therefore mislead investors. Research by Berg et al. (2022) showed that the correlation between ESG ratings across different agencies is only ~0.6, indicating high valuation subjectivity. Elsewhere, Laufer (2003) analysed the effects of greenwashing and stressed that companies often use environmental claims as a marketing strategy, even if their activities do not match those claims. A study by Marquis et al. (2016) found that companies operating in a more stringent regulatory environment are more likely to pursue symbolic actions than substantive change. Lyon and Montgomery (2015) emphasised that a misleading green image can be not only a corporate strategy but also a systemic market problem, in which consumers and investors lack sufficient information to distinguish between true and simulated sustainability.

Various external companies play a significant role in this issue by calculating companies' ESG scores using their established methodologies and thereby informing a wide audience about corporate sustainability trends. However, the question arises: how can

stakeholders assess whether the environmental component of the ESG framework reliably reflects actual environmental investments? Can the discrepancy between these indicators imply misleading green messaging?

Despite the rapid growth of ESG research, significant gaps remain in the literature regarding the E score's ability to reflect companies' real investments and actual environmental impacts. Some studies show that ESG indicators often reflect the quality of information disclosure more than objective performance. For example, Berg et al. (2022) demonstrated that ESG rating divergence among providers is systemic and stems from differing valuation volumes, weights, and measurement methods. This means that the E score is a methodologically conditioned construct that does not necessarily reflect real investment progress. Meanwhile, Kathan et al. (2024) found that ESG scores can be positively associated with the risk of presenting a misleading green image, with high ratings more often correlated with declared rather than actual environmental outcomes.

These findings complement the perspective of signalling theory, according to which ESG indicators can act as reputational signals rather than as accurate indicators of investment performance. The methodologies adopted in the literature in this context rely mainly on regressions (Kathan et al., 2024; Chatterji et al., 2020) and on variances and correlations (Serafeim, 2023; Berg et al., 2022). However, research directly linking the ESG E component to real sustainable investments has not been identified; such research typically assesses discrepancies across sources and environmental quantitative indicators rather than the direct relationship between the E score and actual sustainable capital expenditure.

Thus, it is particularly important not to limit oneself to evaluating the E-score or investment indicators in isolation, but to analyse their relationships. One approach is to compile company phenotypes based on combinations of the E score and actual environmental investments. Such an approach not only identifies relationships between variables but also reveals structural discrepancies and heterogeneous behavioural patterns that often go unnoticed in aggregated regression evaluations. This suggests a need to conduct research to fill this gap by proposing a conceptually and empirically grounded system that integrates E score data with sustainable investments, creating a classification of company phenotypes as an instrument for identifying misleading green images.

2.3. Financial Position, Environmental Governance, and the Role of Stakeholders

The previous section discussed creating a classification of enterprise phenotypes to guide the identification of misleading green images; however, it is important to note that this classification cannot be developed in isolation from the enterprise's financial situation. The discrepancy between the declared data on environmental protection and actual activity was assessed without considering other factors. The real level of investment in environmental protection is the result not only of a strategic choice but also of financial capacity. Therefore, the difference between the declared environmental profile and the actual investments may reflect not only misleading green messaging but also limited access to capital, high financial risk, or short-term liquidity constraints. This makes it critical to assess how companies' environmental governance is affected by their financial health to characterise company phenotypes while accounting for it.

It can be assumed that companies aspire to become sustainable in environmental protection and that this is compatible with their aspiration to become profitable or efficient. Research findings indicate that stronger environmental performance often goes hand in hand with stronger financial performance, especially in the long term (Li et al., 2025; Issa, 2024). However, some sectors observe the opposite effect in the short term—for example, when analysing companies in the tourism sector, high ESG ratings are associated with slightly lower short-term profitability (Matsali et al., 2025). This means that environmental

indicators must be assessed in a complex way, taking into account sector-specific factors and the time horizon. Meanwhile, companies' investments in environmental measures may also be related to various indicators of their financial health, but the nature of this relationship may vary. For example, in an Issa (2024) study, companies investing in CO_2 emissions reduction and energy efficiency improved EBITDA on average.

Elsewhere, Burinskienė et al. (2025) studied resource-intensive companies in Europe and found that environmental ESG indicators are statistically significantly and positively correlated with companies' financial performance, including return on assets (ROA), indicating that investments in environmental solutions can increase financial efficiency. This underlines the strategic value of environmental innovation, especially in sectors where exclusivity is important. Meanwhile, Wagner et al. (2002) found in a scientific study that some companies, especially those operating in capital-intensive sectors (e.g., the paper industry), experienced a negative impact on profitability after significant investments in environmental technologies. The researchers reported that this was due to high initial costs and slow return on investment, especially when the technologies were not effectively integrated into existing production processes.

Finally, in general, scientific studies (see Table 4) show both positive and negative relationships between environmental investments, indicators, and financial results, but specific aspects depend on the context and the indicators chosen for analysis. This link is determined by factors such as the type of environmental investment, the industries and geographical locations of the companies, and is also reflected in the table below (see Table 4).

Table 4. Studies on Financial Position and Environmental Management.

Study	Financial Indicators	Main Research Findings
Deloof (2003)	Turnover of current assets, turnover of receivables, turnover of payables	Empirical results show that more efficient management of inventory, buyer and supplier debt is associated with higher profitability, which has a direct impact on sustainability indicators.
Zorn et al. (2018)	Cash liquidity ratio, net working capital, equity ratio, capitalisation of long-term debt, net debt, net debt/earnings before interest, taxes, depreciation and amortisation	Balanced management of financial indicators has a positive impact on sustainability by strengthening financial stability and reducing the risk of insolvency.
Huynh et al. (2022)	Debt ratio	The increasing debt ratio negatively affects the financial sustainability of companies by increasing the costs of financial risk and financial instability, which reduces the company's ability to ensure long-term stable business development and invest in sustainable initiatives
Carreira et al. (2025)	Return on assets, net profit margin	more profitable companies, as measured by indicators such as ROA and net profit, have statistically significantly higher levels of sustainability (ESG), which confirms the positive relationship between financial profitability and sustainability performance.

Table 4. *Cont.*

Study	Financial Indicators	Main Research Findings
Fu and Jacobs (2022)	Operating margin	In companies that demonstrate operational efficiency, an improvement in water use efficiency is associated with higher profitability and lower risk, but in companies that operate inefficiently, this relationship can have the opposite—negative—effect.
Cong et al. (2022)	Return on equity	Increased investment in environmental initiatives is associated with lower carbon intensity, suggesting that channelling capital towards sustainability contributes to reducing companies' carbon footprint.
Arhinful and Radmehr (2023)	Net debt/earnings before interest, taxes, depreciation and amortisation	The debt-to-EBITDA ratio has a statistically significant negative impact on the financial performance of enterprises, which indicates that higher indebtedness relative to operating profit increases financial risk and reduces the company's ability to ensure sustainable fulfilment of obligations.
Cohen (2023)	Altman Z Indicator	The Altman Z ratio decreases significantly in companies with high environmental (E) and social (S) risks. This means that lower ESG performance directly worsens the components of the Altman Z-ratio/index (profitability, capital structure, liquidity), thus increasing the likelihood of bankruptcy and weakening long-term financial sustainability.
Oestreich and Tsiakas (2024)	Net profit	profitability and carbon intensity are very negative: companies with high carbon intensity have low profitability and vice versa.
Quintiliani (2024)	Return on equity, current and urgent liquidity ratios	Confirms the causal links between ESG practices and various financial indicators, indicating that ESG practices can improve financial performance through more efficient financial management and increased investor confidence
Alves and Meneses (2024)	Net debt	High indebtedness (high net debt) is associated with a higher cost of debt; better ESG performance offsets risks and reduces interest costs for the most indebted companies.
Rodríguez (2024)	Debt service coverage ratio	Sustainable financing is only achieved by aligning the debt service coverage ratio with long-term cash flows.

Table 4. *Cont.*

Study	Financial Indicators	Main Research Findings
Meliza et al. (2025)	ROA and Tobino Q	Companies' carbon reduction strategies are positively correlated with financial performance, including ROA and Tobino Q, indicating that lower carbon intensity increases corporate profitability and market value.
Herman et al. (2025)	ROA, ROE, Net Profit Margin	ESG indicators are positively correlated with companies' financial performance, including ROA and return on equity (ROE), indicating that sustainability factors contribute to increasing profitability and shareholder returns.
Zhang et al. (2025)	Return on assets	Corporate environmental responsibility has different impacts on financial and/or environmental performance.
Del Sarto (2025)	Capitalization of long-term debt	Higher ESG scores reduce the cost of debt and allow for more sustainable capital structuring.
Pérez Estébanez and Sevillano Martín (2025)	Turnover of assets/Turnover of fixed assets	Turnover indicators of assets and fixed assets show how efficiently a company generates income from available resources. Companies that apply sustainability practices are characterized by higher asset turnover, which means better capital productivity, less waste of resources and a more stable long-term business model.

Note. Compiled by the author based on the sources presented in the table.

In summary, the research reviewed generally indicates a consensus that there is a relationship between environmental and financial status, but the direction of the results depends, among other things, on the object under analysis, the indicators used, and the sector in question. The manufacturing sector demonstrates the strongest link between environmental and financial indicators; in the service sectors, ESG transparency and reputation are of greater importance. Thus, the use of different indicators when assessing the environmental relationship with the financial condition of enterprises may contribute to differences in research results, reinforcing the need to determine which indicators of financial condition and efficiency are most important to enterprise stakeholders in the environmental context. This would enable their later use in identifying the characteristics of enterprise phenotypes.

Notably, stakeholders are a broad and heterogeneous group that includes, for example, corporate customers, employees, investors, suppliers, communities, and states. Each interested party may have a different impact on companies' activities, as evidenced by the literature. Singh et al. (2022) conducted a scientific study including 248 small and medium-sized manufacturing enterprises in emerging markets, which found that increased stakeholder pressure significantly increases the level of sustainability initiatives; that is, companies undertake to strengthen their capacity to innovate in an environmentally friendly way. Furthermore, active sustainability initiatives lead to greater green innovation, ultimately improving companies' financial performance. Thus, companies can be said to respond to stakeholder pressure by increasing investments in sustainable activities.

Widyantoro et al. (2025) reached a similar conclusion in a broader context, recognising that stakeholder pressure drives corporate sustainability initiatives. The study by Agyabeng-Mensah et al. (2024) examines the types of stakeholder pressures that most affect sustainability performance and outcomes. The latter authors analyse the impact of 'regulatory' stakeholders (requirements of public authorities and environmental agencies) and 'organisational' stakeholders (pressure from the internal environment: employees, suppliers, and industry associations). According to Agyabeng-Mensah et al. (2024), regulatory pressure has a direct positive impact on the overall outcome of the chain, promoting green manufacturing practices and leading to better environmental and financial performance of companies. Meanwhile, organisational pressure manifests as reputational improvement and innovation but has a weaker direct effect on financial indicators.

Other authors, such as Zhuo (2023), confirm empirical findings that stricter regulation drives green innovation, recognising that strict environmental policies (e.g., the low-carbon cities programme) positively impact green innovation among Chinese companies. Particularly strong impacts have been recorded in private and polluting industries. It has also been found that this policy improves both the performance indicators of the companies themselves and the state of the environment. This confirms that regulation can encourage sustainable investments, with J. Wang and Chen (2024) corroborating this finding: they found that environmental regulation promotes corporate environmental responsibility and green technological innovation, as companies facing pollution taxes increase investments in cleaner technologies.

It is also important to note that researchers—for example, Chen et al. (2025)—have recognised that very stringent (or quickly tightened) environmental standards can shift investment from long-term innovation to short-term compliance, with companies investing 'to comply' rather than creating added value. This can reduce the efficiency of investments and even worsen financial indicators in the short term. Thus, stricter environmental regulation initially increases the operating costs of companies, especially in the short term, but in the long run, such investments usually pay off—energy and raw material costs are reduced, fines for violations are avoided, and the company's reputation among investors and customers improves, which opens up opportunities to attract additional capital or increase sales (Zhuo, 2023; Chen et al., 2025).

Meanwhile, organisational stakeholders such as company employees, suppliers, and partners have a significant indirect impact on sustainability initiatives. Employees are increasingly choosing to work in organisations that value sustainability and social responsibility. Suppliers, especially in international chains, are increasingly demanding compliance with environmental standards, and non-compliance can mean contract termination or additional costs. It is also important to mention that internal pressure from an organisation's management can encourage investment in environmentally friendly solutions. Inocêncio and Favoreto (2022) point out that symbolic sustainability initiatives often stem from the need to meet stakeholder expectations, and employee engagement and supplier pressure can lead organisations to make real changes that also improve financial performance in the long run. Meanwhile, a study by Dyck et al. (2023) shows that pressure from institutional investors and partners drives companies to adopt sustainability practices to enhance long-term reputation and value growth. As such, stakeholders have a significant impact on companies' environmental sustainability.

3. Research Design

The European Union aims to become climate-neutral by 2050, that is, to achieve net-zero GHG emissions (European Commission, 2025a). This goal set by the EU highlights the significance of climate change, which, according to Vaitiekuniene et al. (2024),

impacts corporate governance. The growing focus of corporate stakeholders on climate change is drawing attention to environmental management as part of corporate ESG strategies. Various research results (e.g., Abdullah et al., 2025; Li et al., 2025) confirm that without real investment in environmental protection, it is difficult to achieve significant environmental outcomes.

Ultimately, investments in cleaner technologies, energy efficiency, pollution control, and renewable energy sources are a prerequisite for reducing emissions, optimising resource use, and achieving long-term operational efficiency (Wan et al., 2025; Luo & Zhou, 2025). Most studies (e.g., Abdullah et al., 2025; Li et al., 2025; Wan et al., 2025; Luo & Zhou, 2025) establish a positive bidirectional relationship: better environmental outcomes drive further investment, and the investments themselves lead to improvements in environmental metrics. At the same time, however, it should be noted that these studies are mostly based on the overall size of environmental or ESG expenditure (J. Wang & Chen, 2024; Y. Wang et al., 2021; Xu et al., 2024), without distinguishing whether all these investments actually contribute to environmentally sustainable economic activities.

This indicates the need for a deeper analysis that allows differentiation between the quality of environmental investments and their scope alone. Additional relevance to this issue is provided by the entry into force of the EU Taxonomy Regulation. As of the 2022 financial year, it has become possible to systematically and quantitatively assess CapEx by differentiating between taxonomy-eligible (CapEx-eligible) and taxonomy-aligned (CapEx-aligned) investments. This provides a basis for distinguishing between 'green' investments, which actually contribute to environmental goals, and general or symbolic environmental costs.

It is also important to note that there has been limited research that directly connects the ESG E scores to real sustainable investments or that develops the classification of company phenotypes as an instrument for identifying the misleading green image. The development of such a classification of phenotypes as an instrument would address the asymmetry in signalling theory and information in the context of the sustainable development of the literature and provide investors and regulators with a more reliable analytical tool for identifying misleading green messaging. Furthermore, the discrepancy between the E score and the actual investments cannot be interpreted in isolation from the companies' financial situation. Investing in the environment is not only a strategic choice but also the result of financial capacity. Various researchers (e.g., Li et al., 2025; Issa, 2024) have found that financial indicators significantly affect companies' ability to invest in sustainability, and during economic crises, such investments can be postponed or reduced. Therefore, the mismatch between the E-score and sustainable CapEx may imply not only a misleading green image but also financial limitations.

To properly interpret these discrepancies, it is necessary to assess companies' financial and environmental characteristics in a form relevant to stakeholders. Accordingly, this study develops a classification of company phenotypes based on combinations of ESG E scores, CapEx-eligible investments, and CapEx-aligned investments to determine whether different phenotypes differ statistically in financial and environmental indicators. The development of the research methodology led to the research design presented in Figure 1.

Object and Period of Research

This study analyses European companies, recognising that in recent years the field of sustainability has become one of the most regulated dimensions of the business environment in the European Union (European Commission, 2025a). Sustainability regulatory requirements, which are consistently implemented and expanded at EU level, are fundamentally changing the way companies operate, increasing the scope of disclosure of information on environmental aspects, and increasing requirements for the identification

and justification of real sustainable investments (European Commission, 2025b; KPMG, 2025; PwC, 2025).

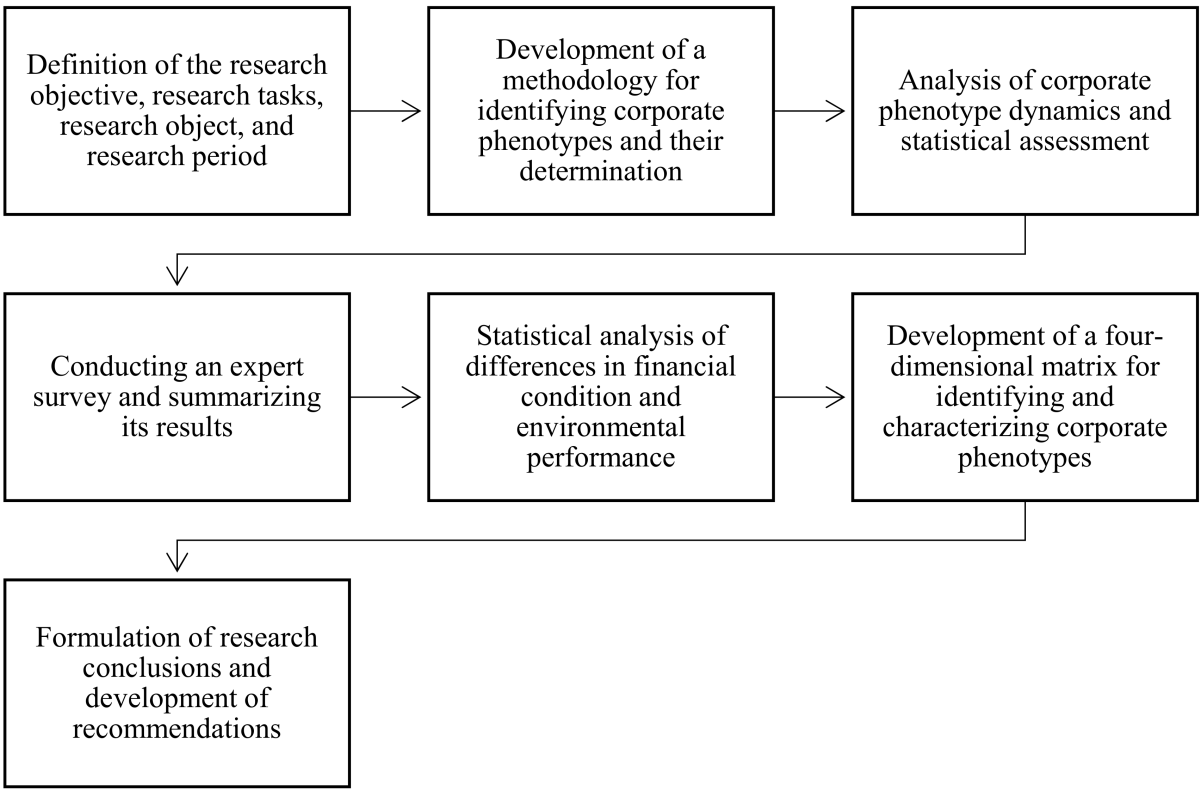

Figure 1. Research Design.

The regulatory instruments that have entered into force and are planned in recent years—such as the EU Taxonomy Regulation and sustainability disclosure requirements—provide an environment for exploring discrepancies between declared environmental assessments and real sustainable capital investments. The study analyses European companies that operate in the EU sustainability regulatory area and whose disclosure data allow assessment of both ESG E scores and investment compliance with the EU Taxonomy criteria. This sample creates the preconditions for a consistent and comparable analysis of enterprise behaviour within a unified regulatory environment and for assessing possible discrepancies between the declared and actual content of environmental activities. Notably, only those companies that have provided data on ESG environmental assessments or EU Taxonomy indicators during the analysis period have been included in the survey sample. Notably, all data were obtained from the Bloomberg Terminal database, enabling the filtering of companies that meet the defined criteria, producing a final sample of 385 European companies (see Appendix A).

In addition, the financial year 2022 of companies was chosen as the start of the investigation period because, as mentioned, this marks the date from which companies have been required to assess not only the taxonomy suitability of activities, but also their compliance with the technical selection criteria for the two European Union climate objectives (European Commission, 2021; EY, 2024). Accordingly, this period marked the beginning of the disclosure of three key taxonomy indicators—turnover, capital expenditure (CapEx), and operating costs (OpEx) (European Commission, 2021). This means that, for the first time, it has been possible to quantify which part of companies' CapEx is sustainable and compliant with the requirements of the EU Taxonomy (KPMG, 2025; EY, 2024).

The end of the survey period (the 2024 financial year) was chosen because companies' sustainability and financial data for 2025 had not yet been published at the time of the survey. Only firms that reported complete data for all three key indicators (Environmental Score, CapEx-eligible investments, and CapEx-aligned investments) in the respective year were included in the final analysis.

3.1. Compilation and Evaluation of Company Phenotypes

As mentioned, three main variables were selected to capture the different dimensions of companies' environmental behaviour.

3.1.1. E Score

The E score, the environmental component of ESG, is interpreted as a sustainability signal from a company to stakeholders. ESG indicators, especially the environmental component, are often interpreted within signalling theory as a means of transmitting information to markets under conditions of information asymmetry (Chu et al., 2025; Del Gesso & Lodhi, 2025).

3.1.2. CapEx-Aligned Investments

Cap-Ex-aligned investments are a part of a capital investment that meets the criteria for environmentally sustainable economic activity set out in the EU Taxonomy Regulation. Unlike ESG ratings, this indicator is considered an objective and regulatory-defined measure of actual actions that allows the identification of the diversion of capital to sustainable economic activities (Cheema-Fox et al., 2025; Bassen et al., 2025).

3.1.3. CapEx-Eligible Investments

CapEx-eligible investments are a proportion of capital investments that are classified as economic activities, included in the EU Taxonomy Regulation, and considered to potentially contribute to environmental objectives. Unlike CapEx-aligned investments, this indicator reflects the eligibility of the activities without confirming their full compliance with all technical selection criteria. Therefore, it is considered an intermediate category between gross capital investments and fully taxonomy-aligned investments, allowing the identification of companies' potential to channel capital towards sustainable economic activities, though it does not always reflect actual environmental impacts (European Commission, 2023a).

3.1.4. Differences Between the Three Indicators

The distinction between taxonomy-eligible and taxonomy-aligned CapEx is critical when interpreting sustainability investment patterns. Taxonomy-eligible CapEx refers to investments directed towards economic activities covered by the EU Taxonomy framework (European Commission, 2023b). However, because eligibility alone does not confirm compliance with the technical screening criteria, it should be viewed as a measure of sustainability potential rather than verified sustainability performance (European Commission, 2023b). In contrast, taxonomy-aligned CapEx refers to investments that fully comply with the technical screening criteria and minimum safeguards set out in the EU Taxonomy Regulation. Consequently, aligned CapEx represents a stronger indicator of actual sustainable transformation. Therefore, firms demonstrating high levels of CapEx-eligible investments but low levels of CapEx-aligned investments may be interpreted as being in a transitional stage (European Commission, 2023b). Such firms have already allocated investments towards activities covered by the Taxonomy regulation but have not yet achieved full regulatory alignment. From a regulatory perspective, these firms may face future compliance challenges, whereas from an investor perspective, they may represent organisations with unrealised sustainability potential. Conversely, firms with high E scores

but persistently low aligned CapEx may raise concerns regarding the credibility of sustainability signals. In such cases, sustainability communication appears to exceed the actual level of taxonomy-compliant investment activity, representing a potential manifestation of the disclosure–implementation gap highlighted in greenwashing literature.

3.2. Evaluation Procedure

The combination of the three variables provides a methodological basis for the development of a phenotype methodology that enables the identification of a discrepancy between declared environmental signals and actual investment actions, which the greenwashing literature defines as a communication-performance gap (Bernini & La Rosa, 2023; Lyon & Montgomery, 2015; Marquis et al., 2016).

To ensure the comparability of different indicators between companies, the three indicators are standardised using the min–max normalisation method (Han et al., 2012):

$$X'_i = \backslash frac\{X_i - X_\{min\}\}\{X_\{max\} - X_\{min\}\} \quad (1)$$

Here, X′_i is the standardised value of the initial indicator for a given company; X_{min} and X_{max} are the smallest and largest values in the sample, respectively.

Min-max standardisation is widely used in empirical financial and sustainability research, where the aim is to equalise indicators of different scales and to form the basis for the formation of typologies or clusters (Han et al., 2012). This transformation allows all indicators to be transferred to the interval [0; 1], thus facilitating their interpretation and comparability and ensuring a consistent basis for the classification of phenotypes. Exception controls will be performed as necessary to increase the robustness and reliability of statistical results.

Theoretical and empirical studies on greenwashing indicate that the discrepancy between communication and actual activity is a critical determinant of greenwashing (Bernini & La Rosa, 2023; Janik & Ryszko, 2025). Based on this logic, the phenotype-based methodology was chosen to derive an environmental score and compare it with real investment/taxonomic capital expenditure.

Enterprise phenotypes are determined using a rule-based classification, whereby the Capex and E scores are first categorised ('High' and 'Low') according to the population average for the corresponding period. Subsequently, each company is assigned high or low values to individual variables. Next, these categories are combined to form different combinations of signals and actions (e.g., High E/Low CapEx). Based on these combinations, each company is assigned a specific phenotype according to predefined logical rules.

Based on the results obtained, a matrix of four phenotypes (2 × 2) is compiled, which allows for classifying companies according to their patterns of environmental behaviour:

1. Over-signalling: high environmental signals and low real sustainable investments.
2. Aligned: signals and real actions are coordinated.
3. Transitional Green: medium-level environmental signals and limited, but growing sustainable investments; this phenotype reflects a transitional state of enterprises, where sustainability principles are being integrated, but full alignment between signalling and real-world action has not yet been achieved.
4. Under-signalling Green: real investments exceed signals, but the overall signal level remains low.

The 4 × 4 matrix is based on the identification of phenotypes across several basic dimensions, each of which is divided into two states: 'High' and 'Low'. In this way, each dimension forms a binary classification, and combinations of several dimensions capture different patterns of company behaviour. By combining these binary states across

all dimensions under consideration, a set of all possible combinations is obtained and structured in matrix form. The 4 × 4 matrix allows for the systematic representation not only of the main cases of alignment (where signals and actions coincide) but also of their discrepancies, which are essential for risk analysis. Such a structure ensures a clear, interpretable, and logically complete typology that encompasses all possible combinations of signals and actions.

The application or compilation of typologies in the scientific literature is recommended to reveal the heterogeneity of corporate behaviour, which often goes unnoticed in mean regression models (Janik & Ryszko, 2025). In this context, to verify the empirical validity of the phenotypes, this study will apply cluster analysis, which allows assessment of whether the theoretically defined structure of the four phenotypes has an actual equivalent in the observed data space, without imposing grouping boundaries in advance.

The identification of phenotypes takes place in two stages. In the first phase, hierarchical cluster analysis is applied using the Ward method and the Euclidean distance metric. The distance between the first and next observations in multidimensional space is defined as follows (Rodriguez et al., 2019; Randriamihamison et al., 2021):

$$d_ik = \sqrt{\left(\sum_(j = 1)\hat{}m(z_ij - z_kj)\hat{}2\right)} \tag{2}$$

Here d_ik is the distance between the first and third observations in the space of multidimensional signs; i, k—surprising (enterprise) indices; j—indicator index; m—the number of indicators used for clustering; z_ij and z_kj are standardised values of the nth indicator for the first and third companies, respectively.

$$W = \sum_(g = 1)\hat{}G \sum_(i \in g)\|z_i - \mu_g\|\hat{}2 \tag{3}$$

Here, W is the sum of the internal variance of the clusters, minimised in the grouping process; G is the number of clusters; g is the index of a specific cluster; i ∈ g represents the observations (enterprises) assigned to the g cluster; z_i is the vector of the first observation of standardised indicators; μ_g refers to the vector of the centroid of the g cluster; ‖·‖ is the Euclidean norm (Strauss & von Maltitz, 2017; Randriamihamison et al., 2021).

At this stage, the analysis of dendrograms allows for empirically evaluating the optimal cluster structure and verifying that four distinct groups correspond to the theoretical matrix of phenotypes 2 × 2 spontaneously formed in the data.

In the second stage, based on the results of the hierarchical analysis, non-hierarchical cluster analysis (k-means) will be applied to stably assign each observation to a specific cluster. The 'k-means' algorithm iteratively minimises the internal variance of clusters (Rodriguez et al., 2019; Vichi et al., 2022):

$$min \sum_(g = 1)\hat{}k \sum_(i \in g)\|z_i - \mu_g\|\hat{}2 \tag{4}$$

$$\mu_g = (1/n_g) \sum_(i \in g)z_i \tag{5}$$

Here, k is the predetermined number of clusters; g is the cluster index; i ∈ g is the observations assigned to the respective cluster; z_i is the vector of the first observation of standardised indicators; μ_g is the centroid of the g cluster; μ_g is the vector of the centroid of the g cluster; n_g is the number of observations (enterprises) assigned to the g cluster; z_i is the vector of the first observation of standardised indicators (Vichi et al., 2022; Wani, 2024).

The resulting clusters will be interpreted and compared with theoretically defined phenotypes by analysing cluster indicator averages and their distributions. This methodological approach allows cluster analysis to be treated as an empirical procedure for

validating phenotypes, confirming whether the theoretical 2 × 2 typology (based on the interaction between signals and real actions) corresponds to the actual data structure and forms the basis for further comparative analysis of phenotypes.

To assess the stability of phenotypes and their variation over time, a matrix of phenotype transitions is compiled, defining the probabilities of transition from one phenotype to another between periods (Collins & Lanza, 2010; Moore et al., 2025):

$$p_\{ij\} = P(Fenotipas_\{t+1\} = j \backslash mid\ Fenotipas_t = i) \quad (6)$$

Here, p_{ij} is the probability of transition from state i to state j.

The application of transition matrices enables analysis of the stability and transition stages of behavioural states, which is why this study will be conducted (Collins & Lanza, 2010; Moore et al., 2025).

In addition, to assess the temporal stability of the proposed classification framework, phenotype transition matrices were analysed across the 2022–2023 and 2023–2024 periods. Although firms exhibited heterogeneous shifts among phenotypes, the four-phenotype structure remained consistently identifiable throughout the study period, supporting the conceptual validity and temporal stability of the proposed classification framework. Prior to clustering, all variables were standardised using min–max normalisation, thereby reducing the impact of differing measurement scales on the clustering results.

3.3. Expert Survey

The next stage of the research involved surveying experts to assess which of the identified financial and environmental indicators are most important to corporate stakeholders, who, as noted in the first chapter, significantly impact corporate governance in the context of sustainability. The survey is reproduced as Appendix B. This survey approach was chosen because resolving the research problem requires specialised knowledge that only specialists in finance and sustainability possess.

Expert evaluation is often described as the set of opinions of professionals with relevant knowledge and experience. This method is applied when the problem requires knowledge of a specific area (Vaicekauskas, 2015). The process of expert evaluation begins with selecting suitable experts and determining a suitable sample size (Pabedinskaitė & Vitkauskas, 2009)—only after interviewing a sufficient number of specialists from the target group can reliable results be expected. Because, as already established, companies are exposed to both external and internal stakeholders, such as suppliers and buyers, the decision was made to interview experts in finance and sustainability. This is because these professionals occupy an intermediate position between the expectations of internal and external stakeholders.

Financial experts are directly responsible for analysing the impact of strategic decisions on financial performance and investor assessments, while sustainability professionals integrate environmental requirements arising from regulatory and societal pressure into the company's internal processes. For this reason, both types of experts offer approaches that enable them to evaluate the relationships among sustainable investments, environmental performance, and financial indicators. In addition, it is assumed that financial and sustainability experts play a key role in ensuring transparency and accountability to capital markets for listed companies; therefore, their assessments are to be considered professionally sound and of practical significance.

Accordingly, a survey of experts in these fields has been conducted to achieve the study's objective. In addition, to ensure higher survey quality, a limited number of experts is usually selected (Dikčius, 2011). According to Podzenko (2005), 13 experts are sufficient, whereas Tsyganok and Kadenko (2010) states that the maximum recommended number of

respondents is seven. This study reached a middle ground by surveying 10 scientists and 10 people working in the finance and sustainability sectors for a total of 20 respondents, based on the selection of two distinct groups. In addition, more recent studies show that the sample size is not strictly standardised in expert surveys, but usually ranges from around 20 to 30 participants (Škrinjar et al., 2026). At the same time, it is emphasised that the results can be reliable even with smaller groups, provided that heterogeneity and high expert competence are ensured (Ciritel et al., 2024). Although it has been found that in the case of multiple interest groups, it is recommended to have 20–30 experts in each group, smaller studies with 10–20 respondents are also widely applied in practice, especially when the objective of the study is a deeper qualitative analysis (Manyara et al., 2024). Given these additional recommendations, the chosen sample size is considered appropriate, as it aligns with common practice in expert studies and ensures sufficient diversity of opinions and reliable results.

According to Benner (1984), an expert assessment should be carried out by interviewing specialists who have accumulated sufficient experience and, as a result, have acquired a deep knowledge of the object under study. Therefore, in this study, experts in finance and sustainability, as well as scientists with more than 5 years of work experience, were included, as this period is considered sufficient to acquire the necessary professional experience (Vaicekauskas, 2015).

According to Dikčius (2011), evaluating expert opinions often does not yield a factual picture of the study object because experts' opinions and attitudes toward the problem often differ. As such, it is important to assess the degree of compatibility among the experts' opinions. Therefore, to determine the level of compatibility among experts, the Kendall concordance coefficient is calculated in IBM SPSS Statistics version 29.0 (Podzenko, 2005) using the following formula:

$$W = 12S/(n\hat{}2\ (m\hat{}3 - m))\ (5) \tag{7}$$

Here, S refers to the real sum of squares, n indicates the number of respondents, and m is the number of alternatives.

The Kendall concordance coefficient is most commonly used as a criterion for assessing the compatibility of expert opinions (Vaicekauskas, 2015). Moreover, according to Podzenko (2005), only the ranking of expert indicators is suitable for calculating this coefficient when the indicators are ranked. After calculating the concordance criterion, it is evaluated whether the indicator value is close to 1 or 0. Expert opinion is considered unanimous when the coefficient of concordance is close to 1. When the coefficient approaches 0, it means that experts do not have a unanimous opinion (Podzenko, 2005). When the concordance coefficient exceeds 0.6, the experts' opinions are considered sufficiently unanimous for the expert assessment to be considered reliable and complete (Malhotra & Birks, 2007).

To collect expert opinions, an electronic survey was developed. The survey used a 7-point Likert scale—with responses ranging from 'strongly disagree' to 'strongly agree'—to assess respondents' overall opinions on specific environmental and financial metrics (Dikčius, 2011). A 7-point Likert scale was adopted because it provides sufficient variation in the data.

The survey enabled experts to rank the indicators presented in Appendix C. Notably, to select indicators for further investigation in the study, the average points assigned to each indicator were calculated. Indicators with scores below the overall average were excluded from further analysis.

3.4. Environmental and Financial Management Characteristics of Enterprise Phenotypes

Based on the results of the expert survey, financial and environmental quantitative characteristics are calculated for each identified phenotype (Fake Green, Aligned, Silent Green, Under-Signalled Green). To determine whether the different company phenotypes formed by E-score compliance and CapEx-aligned and -eligible investments differ statistically in financial and environmental indicators, a statistical test of group comparison is performed. Taking into account the characteristics of the data distribution, possible deviations from the norm, and the presence of extreme values, a nonparametric Kruskal–Wallis test was chosen, with statistical significance assessed based on a p-value at a materiality level of 5% (i.e., $p < 0.05$).

The chosen method allows for an empirical assessment of whether the observed differences between phenotypes are not random, certain financial or environmental indicators distinguish specific phenotypes, and the classification of phenotypes has not only conceptual but also statistical validity. Statistically significant results are interpreted as evidence that different phenotypes reflect real, systemic differences in the behaviour of companies with respect to both financial efficiency and environmental impact.

Summarising the previous stages led to the development of a matrix of four phenotypes that serves as a systematic analytical tool for the identification and classification of companies. This matrix combines signalling dimension (E score); real-world dimension (CapEx); and financial and environmental quantitative characteristics.

The matrix allows for not only assigning companies to a specific phenotype but also for immediately identifying the financial and environmental traits inherent in each phenotype. As such, the matrix of phenotypes represents not only conceptual research results but also a practical diagnostic tool for investors, regulators, and corporate executives, as well as a basis for further analyses of phenotype dynamics.

By following the methodology presented in this chapter, the study develops a tool to identify green corporate image messaging.

4. Results

4.1. Cluster Analysis

The 2022–2024 cluster analysis, based on indicators of environmental disclosures (E scores) and capital investment indicators related to the EU Taxonomy regulation (CapEx-aligned investments and CapEx-eligible investments), reveals consistent differences among companies in their levels of sustainability disclosure and investment compatibility. These differences enable the identification of not only statistical clusters but also conceptual 'phenotypes' of companies, reflecting distinct sustainability strategies. In 2022, clusters differentiate companies based on whether sustainability communication (environmental disclosures) is conditioned by the real integration of sustainability taxonomies into investments.

The over-signalling cluster recorded the highest level of environmental disclosures (Env Disc = 0.72), but its taxonomic CapEx scores were relatively low (eligible = 0.07, aligned = 0.06). This shows that intensive communication does not always correspond to the investment structure and can indicate the direction of greenwashing risk (communication outperforms implementation). Meanwhile, the aligned cluster stood out not so much for its maximum disclosures (Env Disc = 0.45) as for its particularly high taxonomy integration level: eligible CapEx reached 0.21, while aligned CapEx reached as much as 0.78. This means that this group has a notable alignment of investments with the EU taxonomy and can be treated as taxonomy leaders. The under-signalling green cluster was characterised by a low disclosure rate (0.16) and extremely low taxonomy integration (eligible = 0.05, aligned = 0.02), while the transitional green cluster recorded both an average disclosure rate (0.43) and limited compatibility (eligible = 0.06, aligned = 0.04). The latter profile

can be interpreted as a transitional stage of maturity: disclosures are already higher, but investment compatibility has not yet been achieved.

In 2023, the structure remained largely the same, but the order clusters changed. The aligned cluster was characterised by high taxonomic indicators: Env Disc = 0.47, eligible = 0.18, aligned = 0.71. The aligned rate remained high (0.71), confirming the stability of this phenotype over time. Over-signalling was characterised by a high disclosure rate (0.68) and low-medium taxonomic compatibility (eligible: 0.07; aligned: 0.07), meaning that a relatively large proportion of the analysed companies focus on disclosure, but not on real investment transformation.

In 2024, the cluster order remained unchanged. The aligned cluster was characterised by both a high disclosure rate (0.55) and high taxonomic indicators (eligible: 0.18; aligned: 0.71). This shows that taxonomy leaders not only maintain investment compatibility but also increase the volume of communication/disclosures, approaching a 'balanced' sustainability profile. Over-signalling in 2024 (Cluster 4) was characterised by a high disclosure rate (0.69) and relatively low taxonomic indicators (eligible: 0.08; aligned: 0.05). Transitional green recorded an average disclosure rate (0.43) and a slightly higher eligible share (0.09), but aligned CapEx remained very low (0.02). This combination reinforces the interpretation that in the transitional phenotype, companies can start to identify taxonomically appropriate investments (eligible), but their alignment remains insufficient, possibly due to technical criteria. Finally, Under Signal Green remained a group of low disclosures (0.19) and minimal taxonomic integration (eligible: 0.07; aligned: 0.01). This shows (Table 5) that some companies remain at an early stage, both in terms of communication and the practical implementation of taxonomy.

Table 5. Cluster-level Mean Values for Environmental Disclosure and EU Taxonomy metrics (2022–2024).

Cluster	Environmental Disclosure: 2022C	CapEx EU Tax Eligible: 2022C	CapEx EU Tax Aligned: 2022C
1 (Undersignalled Green)	0.16	0.05	0.02
2 (Oversignalling)	0.72	0.07	0.06
3 (Transitional green)	0.43	0.06	0.04
4 (Aligned)	0.45	0.21	0.78
Cluster	**Environmental Disclosure: 2023C**	**CapEx EU Tax Eligible: 2023C**	**CapEx EU Tax Aligned: 2023C**
1 (Aligned)	0.47	0.18	0.71
2 (UnderSignalled Green)	0.12	0.06	0.04
3 (Oversignalling)	0.68	0.07	0.07
4 (Transitional green)	0.38	0.06	0.02
Cluster	**Environmental Disclosure: 2024C**	**CapEx EU Tax Eligible: 2024C**	**CapEx EU Tax Aligned: 2024C**
1 (Transitional green)	0.43	0.09	0.02
2 (Aligned)	0.55	0.18	0.71
3 (UnderSignalled Green)	0.19	0.07	0.01
4 (Oversignalling)	0.69	0.08	0.05

Note. Compiled by the author based on data from the Bloomberg database.

In summary, the clusters consistently show that the main differentiation factor is aligned CapEx, with the group with a significantly higher level of harmonised CapEx standing out in each year (0.78 in 2022; 0.71 in 2023; 0.71 in 2024). Meanwhile, the oversignalling cluster consistently recorded the highest environmental disclosure scores (0.72 in 2022; 0.68 in 2023; 0.69 in 2024), but did not achieve a correspondingly high aligned

CapEx in any year. This confirms the existence of the disclosure–implementation gap and enables the identification of different sustainability phenotypes, where the communication dimension (disclosure) is independent of the investment transformation (aligned and eligible CapEx).

The charts presented in Figure 2 consistently reveal that the distribution of enterprises in 2022 by environmental disclosures and EU taxonomy indicators is not homogeneous; rather, clear, repetitive profiles emerge. It is apparent that the biggest differences between clusters do not arise from environmental disclosures but from taxonomy-aligned CapEx. Meanwhile, the environmental disclosures indicator is more evenly distributed and often does not coincide with a high level of investment compatibility. This discrepancy is particularly evident in clusters where high environmental scores are recorded but do not correspond to high levels of CapEx, thus visually confirming the gap between disclosure and real-world implementation.

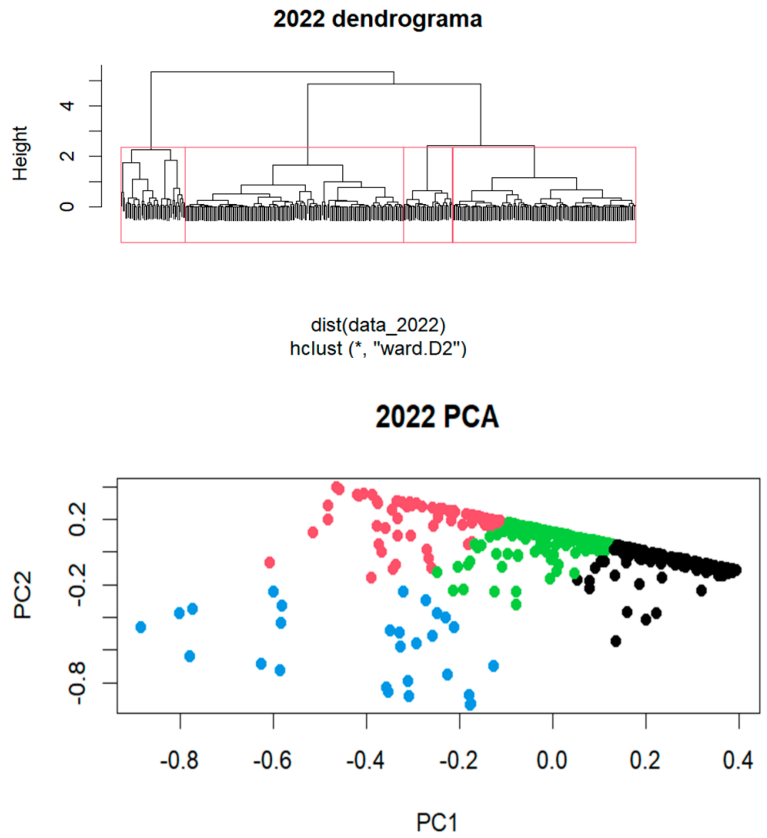

Figure 2. 2022 Distribution of Enterprises by Principal Component Analysis (PCA): Cluster Structure by Environmental Disclosures and Taxonomy Indicators, and 2022 Hierarchical Clustering of Enterprises: Dendrogram Revealing the Cluster Formation Structure. Note. Compiled by the author based on data from the Bloomberg database. Colored points represent the clusters identified through hierarchical clustering: blue = Undersignalled Green (Cluster 1), red = Oversignalling (Cluster 2), green = Transitional Green (Cluster 3), and black = Aligned (Cluster 4).

The charts also show intermediate cases where taxonomy-appropriate (eligible) CapEx has increased but has not yet achieved a high level of harmonised CapEx, indicating a transitional stage of sustainability integration. In summary, the charts enable the clear identification of four distinct company phenotypes—from low integration to taxonomy leaders—and show the main trend that high disclosure does not, in itself, ensure high investment compatibility with the EU taxonomy.

The 2023 graphs (Figure 3) show a significant redistribution of the cluster structure compared to 2022, but the main phenotypic differences remain identifiable. Visually, the most striking element is the increase in taxonomy-aligned CapEx, even as it remains low in other clusters. The graphs also reinforce that the highest level of environmental disclosures is recorded by cluster 3 (about 0.68), but the matched CapEx remains at a medium level (~0.07). Next, cluster 2 clearly stands out as a 'low integration' group—all three indicators in this segment are low, which indicates the minimum level of both disclosures and taxonomy principles. Cluster 4 occupies an intermediate position: despite medium environmental disclosures (~0.38), matched CapEx remains low (~0.02). As such, this cluster can be interpreted as a 'transitional' phenotype, where some focus on disclosures already exists, but investment integration has not yet been achieved.

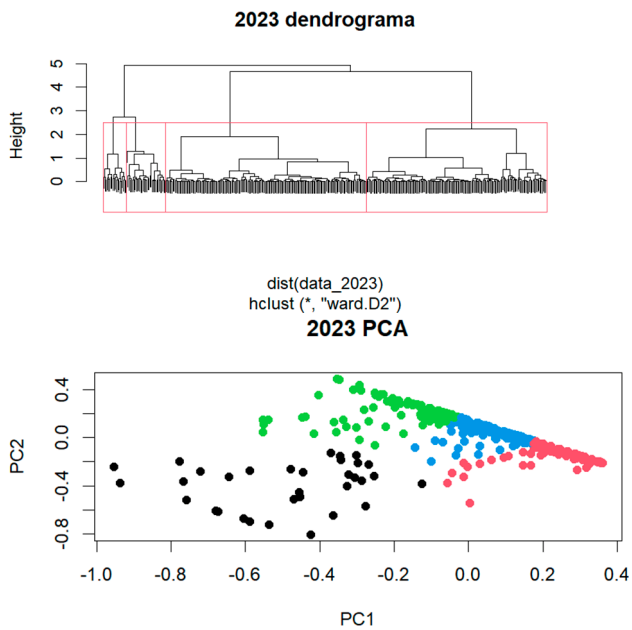

Figure 3. 2023 Distribution of Enterprises by Principal Component Analysis (PCA): Cluster Structure by Environmental Disclosures and Taxonomy Indicators, and 2023 Hierarchical Clustering of Enterprises: Dendrogram Revealing the Cluster Formation Structure. Note. Compiled by the author based on data from the Bloomberg database. Colored points represent the clusters identified through hierarchical clustering: black = Undersignalled Green, blue = Transitional Green, red = Aligned, and green = Oversignalling.

In summary, the 2023 graph confirms that the main cluster differentiator remains taxonomy-aligned CapEx. Analysing the 2024 charts presented in Figure 4 confirms the trends observed in previous years.

In summary, the 2024 graph visually represents the four main phenotypes. Of particular importance, the visual results once again show a weak relationship between environmental disclosures and real investment compatibility: a high disclosure score is not a sufficient predictor of high levels of aligned CapEx. This leads to the conclusion that corporate sustainability strategies remain heterogeneous in 2024, and some companies still prioritise disclosure over its practical implementation through investments.

Analysing cluster transitions between 2022 and 2024 allows us to assess not only the static phenotypes of companies, but also their dynamics, that is, how companies have shifted between different sustainability profiles. The structure of period transitions presented in Table 6 shows that sustainability phenotypes are dynamic and non-linear: companies do not only move between clusters 'upwards' but also experience reverse transitions. The most stable and conceptually significant result is a consistently high

probability of transition from cluster 3 to cluster 4 (0.77 in both periods), enabling the characterisation of cluster 3 as a critical 'tipping point' from which it is most likely to move to the highest sustainability profile.

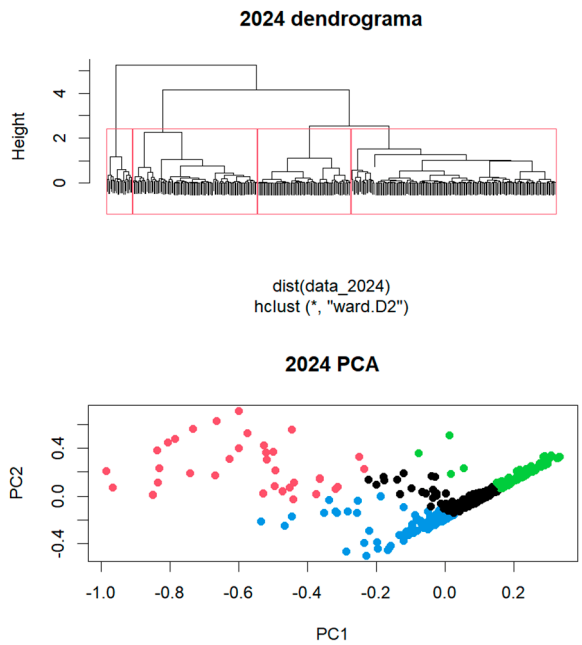

Figure 4. 2024 Distribution of Enterprises by Principal Component Analysis (PCA): Cluster Structure by Environmental Disclosures and Taxonomy Indicators, and 2024 Hierarchical Clustering of Enterprises: Dendrogram Revealing the Cluster Formation Structure. Note. Compiled by the author based on data from the Bloomberg database. Colored points represent the clusters identified through hierarchical clustering: black = Transitional Green, blue = UnderSignalled Green, red = Oversignalling, and green = Aligned.

Table 6. Cluster Transitions for the Periods 2022–2023 and 2023–2024.

Transitions (2022–2023)			
1 (Under-signalled Green)	2 (Over-signalling)	3 (Transitional Green)	4 (Aligned)
-	0.64	0.01	0.36
0.03	-	0.91	0.07
0.06	0.02	0.15	0.77
0.79	0.04	0.11	0.07
Transitions (2023–2024)			
1 (Under-signalled Green)	2 (Over-signalling)	3 (Transitional Green)	4 (Aligned)
0.09	0.79	0.03	0.09
0.34	-	0.63	0.02
0.19	0.04	-	0.77
0.66	0.03	0.18	0.13

Note. Compiled by the author based on data from the Bloomberg database.

In summary, the analysis of transitions shows that enterprise movement between clusters is intense and heterogeneous, yet four main phenotypes remain consistent.

The graph in Figure 5 shows the 2022–2024 averages of the three indicators by cluster, enabling comparison of overall trends over time. The chart reveals that the averages of environmental disclosures and eligible CapEx remain relatively stable, fluctuating in a small range (around 0.3–0.5 and 0.08–0.12), while aligned CapEx demonstrates the most fluctuations, peaking in 2022 (~0.23) before declining significantly in 2023 (~0.21)

and falling further in 2024 (~0.20). This shows that while environmental disclosures and taxonomy-eligible investments remain relatively consistent, the real coherence of investments with the EU taxonomy has decreased over time, confirming that progress in this area is not consistent and may face challenges in practical implementation amid tightening sustainability regulation.

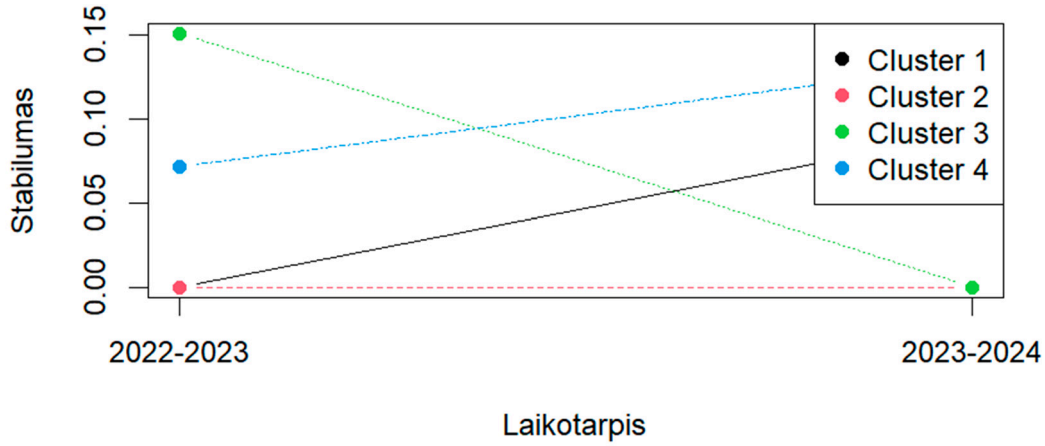

Figure 5. Dynamics of Environmental Disclosures and Taxonomy-Aligned Investments: Comparison of Averages by Cluster 2022–2024. Note. Produced by the author based on data from the Bloomberg database.

A cluster analysis conducted between 2022 and 2024 showed that companies consistently grouped into four different phenotypes based on environmental disclosures and EU taxonomy CapEx indicators. Although the identified phenotypes remain stable throughout the analysed year, their composition varies, and the analysis of transitions reveals intense, heterogeneous movement of enterprises between clusters. It is important that both cluster centres and graphical analyses consistently illustrate the gap between environmental disclosures and real investment compatibility, allowing the conclusion that high sustainability disclosure is an insufficient condition for the effective implementation of EU taxonomy principles.

4.2. Expert Survey Results

As mentioned, 20 experts were surveyed. To assess the level of consensus across the surveys, a concordance coefficient of 0.72 was calculated. This indicates the compatibility of expert opinions. Table 7 presents the results of the expert survey, distinguishing the indicators according to the rules specified in the methodology. These results are used for further analysis.

Table 7. Summary of the results of the expert survey.

	Average Score:	**4.21**	
Ratio Type	**Ratio Name**	**Score**	**Above Average Score?**
Profitability:	Net Profit Margin	6.84	Yes
	Gross Margin	4.05	-
	Operating Margin	4.16	-
	EBITDA Margin	3.58	-
	Return on Assets	6.58	Yes
	Return on Equity	6.47	Yes

Table 7. *Cont.*

	Average Score:	4.21	
Ratio Type	**Ratio Name**	**Score**	**Above Average Score?**
Liquidity:	Current Ratio	6.05	Yes
	Quick Ratio	4.21	-
	Cash Ratio	4.21	-
	Net Working Capital—NWC	4.05	-
	Working Capital Ratio	3.84	-
Financial leverage:	Debt Ratio	5.95	Yes
	Debt to Equity	3.63	-
	Equity Ratio	6.16	Yes
	Long-Term Debt to Capitalization Ratio	3.21	-
	Net Debt	3.05	-
	Net Debt/EBITDA	4.06	-
	Altman Z-score	3.05	-
	Debt Service Coverage Ratio	3.37	-
Efficiency Ratio:	Asset Efficiency Ratio	3.11	-
	Fixed Asset Efficiency Ratio	3.11	-
	Inventory Efficiency Ratio	2.79	-
	Receivables Efficiency Ratio	4.21	-
	Payables Efficiency Ratio	4.11	-
ESRS E1—Climate change:	GHG Emissions—Scope 1, 2, 3 and Total (tCO_2e)	6.95	Yes
	GHG Emission Intensity—tCO_2e per revenue unit	6.95	Yes
	Energy Consumption and Energy Mix—MWh, % renewable	4.16	-
	GHG Removals and Carbon Credits—tCO_2e	3.74	-
	Expected Financial Impact of Climate Risks/Opportunities—EUR	3.53	-
ESRS E2—Pollution:	Microplastics Quantity—kg or t	3.74	-
	Pollutant Emissions to Air, Water and Soil—tonnes	3.79	-
	Use of Substances of Concern—tonnes	3.79	-
	Substances of Very High Concern—SVHC—tonnes	4.11	-
	Expected Financial Impact of Pollution-Related Risks/Opportunities—EUR	4.05	-
ESRS E3—Water and marine resources:	Total Water Consumption—m^3	4.11	-
	Water Consumption in Water-Stress Areas—m^3	3.53	-
	Reused and Recycled Water—m^3	4.11	-
	Change in Stored Water—m^3	3.16	-
	Water Use Intensity—m^3 per product unit or per €	4.05	-
	Expected Financial Impact of Water-Related Risks/Opportunities—EUR	4.21	-
ESRS E4—Biodiversity and ecosystems:	Sites in Biodiversity-Sensitive Areas—number and ha	3.47	-
	Expected Financial Impact of Biodiversity-Related Risks/Opportunities—EUR	4.05	-

Table 7. *Cont.*

	Average Score:	4.21	
Ratio Type	**Ratio Name**	**Score**	**Above Average Score?**
ESRS E5—Resource use and circular economy:	Resource Inputs: Quantity of Materials Used—tonnes	2.62	-
	Resource Inputs: Use of Secondary Raw Materials—tonnes, %	4.00	-
	Resource Inputs: Share of Sustainable Biobased Materials—%	3.95	-
	Resource Outputs: Product Circularity Indicators—% recycled, durability	4.00	-
	Resource Outputs: Waste Generation and Treatment—tonnes	4.00	-
	Expected Financial Impact of Resource-Use-Related Risks/Opportunities—EUR	4.21	-

Note. Produced by the author based on data from the Bloomberg database.

Based on the results presented, the following indicators have been used in the further analysis: Net Profit Margin, ROA (Return on Assets), ROE (Return on Equity), Current Liquidity Coefficient, Current Ratio, Debt Ratio, Equity Ratio, GHG Emissions (Scope 1, 2, 3 and Total [tCO_2e]), and GHG Emission Intensity (tCO_2e per revenue unit).

4.3. Analysis of the Environmental and Financial Management Characteristics of Company Phenotypes

To determine whether the phenotypes of companies formed based on the ESG E score and CapEx indicators differ significantly, a statistical group comparison test was conducted. Taking into account the characteristics of the data distribution, the non-parametric Kruskal–Wallis test was used to assess whether the distributions of several independent groups differ significantly. Table 8 presents the results.

Table 8. Results of Statistical Significance Testing.

	2022		
Indicators	Chi_square	df	*p*_value
Net Profit Margin_22	17.18	3.00	0.00
ROA (Return on Assets)_22	28.44	3.00	0.00
ROE (Return on Equity)_22	18.71	3.00	0.00
Current liquidity ratio (Current Ratio)_22	1.20	3.00	0.75
Debt Ratio_22	6.84	3.00	0.08
Equity Ratio_22	6.84	3.00	0.08
GHG Intens/Sls:2022C	20.18	3.00	0.00
GHG Scope 1:2022C	22.88	3.00	0.00
GHG Scope 2 Loc Based:2022C	31.35	3.00	0.00
GHG Scope 3:2022C	30.79	3.00	0.00
GHG Scope 2 Mkt Based:2022C	13.86	3.00	0.00

Table 8. *Cont.*

2023			
Indicators	Chi_square	df	*p*_value
Net Profit Margin_23	5.80	3	0.12
ROA (Return on Assets)_23	20.21	3	0.00
ROE (Return on Equity)_23	12.42	3	0.01
Current liquidity ratio (Current Ratio)_23	14.39	3	0.00
Debt Ratio_23	7.60	3	0.06
Equity Ratio_23	7.60	3	0.06
GHG Intens/Sls:2023C	21.73	3	0.00
GHG Scope 1:2023C	15.80	3	0.00
GHG Scope 2 Lock Based:2023C	22.53	3	0.00
GHG Scope 3:2023C	17.86	3	0.00
GHG Scope 2 Mkt Based:2023C	14.65	3	0.00
2024			
Indicators	Chi_square	df	*p*_value
Net Profit Margin_24	4.21	3	0.24
ROA (Return on Assets)_24	17.48	3	0.00
ROE (Return on Equity)_24	13.20	3	0.00
Current liquidity ratio (Current Ratio)_24	2.17	3	0.54
Debt Ratio_24	7.75	3	0.05
Equity Ratio_24	7.75	3	0.05
GHG Intens/Sls:2024C	35.20	3	0.00
GHG Scope 1:2024C	34.59	3	0.00
GHG Scope 2 Lock Based:2024C	42.76	3	0.00
GHG Scope 3:2024C	23.99	3	0.00
GHG Scope 2 Mkt Based:2024C	18.50	3	0.00

Note. Compiled by the author based on data from the Bloomberg database.

Based on the Kruskal–Wallis test (df = 3), the different company phenotypes differ statistically significantly across the period 2022–2024 for most environmental indicators. In all the years analysed, significant differences are observed in both GHG intensity and in Scope 1, Scope 2 (location-based and market-based), and Scope 3 emission metrics ($p < 0.05$). In terms of financial indicators, the most stable and consistent differences between phenotypes appear for ROA and ROE ($p < 0.05$ for the whole year), while the differences in the Net Profit Margin are only significant in 2022 and the differences in the current liquidity ratio only in 2023. Capital structure indicators (Debt Ratio and Equity Ratio) are marginal in most cases ($p \approx 0.05$–0.08), suggesting that differences between phenotypes are weaker and less stable over time.

Based on the phenotype analysis, clear differences between the financial and environmental characteristics of the companies are identified for the period 2022–2024; these differences vary over time and reveal the dynamic characteristics of the phenotypes, as Table 9 illustrates.

Table 9. *Phenotype* Characteristics.

Phenotype	Average of GHG Scope 3:2022C	Average of ROE (Return on Equity)_22	Average of GHG Intens/Sls:2022C	Average of GHG Scope 2 Mkt Based:2022C	Average of GHG Scope 1:2022C	Average of ROA (Return on Assets)_22	Average of GHG Scope 2 Loc Based:2022C
1 (Under-Signal Green)	Low	High	Low	Low	Low	High	Low
2 (Over signaling)	Low	Low	High	High	High	Low	High
3 (Transitional green)	High	Low	Low	Low	Low	Low	High
4 (Aligned)	High	High	Low	Low	High	High	High
Phenotype	Average of ROA (Return on Assets)_23	Average of GHG Scope 2 Mkt Based:2023C	Average of GHG Scope 2 Loc Based:2023C	Average of GHG Scope 1:2023C	Average of GHG Scope 3:2023C	Average of GHG Intens/Sls:2023C	Average of ROE (Return on Equity)_23
1 (Aligned)	High	Low	Low	Low	Low	Low	Low
2 (Under-Signal Green)	Low	High	High	High	Low	High	Low
3 (Over signaling)	Low	High	High	High	High	High	Low
4 (Transitional green)	Low	High	High	High	High	High	Low
Phenotype	Average of GHG Scope 2 Loc Based:2024C	Average of GHG Scope 3:2024C	Average of GHG Intens/Sls:2024C	Average of GHG Scope 2 Mkt Based:2024C	Average of GHG Scope 1:2024C	Average of ROA (Return on Assets)_24	Average of ROE (Return on Equity)_24
1 (Transitional green)	Low	Low	Low	Low	Low	High	High
2 (Aligned)	High	High	High	High	High	Low	Low
3 (Under-Signal Green)	Low	Low	Low	Low	Low	High	High
4 (Over signaling)	High	High	High	High	High	High	High

Note. The average indicator values of each cluster determined which indicators correspond to the high level and which to the low level, identifying different company phenotypes. Table compiled by the author based on data from the Bloomberg database.

Based on the results of the phenotype analysis, in the period 2022–2024, clear differences between the financial and environmental characteristics of companies were identified, which varied over time and revealed the dynamic characteristics of phenotypes. In 2022, based on phenotypic characteristics, a relatively clear distinction can be seen between financial performance and emission profiles. The under-signalled green phenotype is characterised by low emission intensity and low emissions across all GHG dimensions, but mixed financial results, with high ROA and lower ROE. Meanwhile, the over-signalling phenotype is characterised by the opposite combination—high emission intensity, high Scope 1 and Scope 2 emissions, and weak financial results—indicating a potential mismatch between signalling and actions. The transitional green phenotype is characterised by a heterogeneous emission profile—high Scope 3 emissions but low overall emission intensity and weak financial indicators—which allows it to be interpreted as transitional. The aligned phenotype is distinguished by high financial indicators (ROA and ROE) but also by high absolute emissions (especially Scope 1 and Scope 3). However, the intensity of emissions remains low, which may indicate more efficient use of resources in large-scale activities.

In 2023 saw a more pronounced distribution of phenotypes according to emission indicators. The aligned phenotype reflects the most favourable environmental profile during this period, with low emissions across all GHG dimensions and high ROA, although the ROE remains low. The remaining phenotypes (Under-signalled Green, Over-signalling, and Transitional Green) exhibited higher emission levels, particularly in the Scope 1 and Scope 2 dimensions. The Over-signalling and Transitional Green phenotypes also stand out for their high Scope 3 emissions, which have a greater impact across the value chain. However, these phenotypes are all characterised by low levels of the financial indicators (ROA and ROE), suggesting that higher emissions are associated with lower financial efficiency over this period. Thus, in 2023, only the Aligned phenotype could combine lower emissions with relatively better financial efficiency.

In 2024, the differences in phenotypes were more clearly structured into two main groups according to emissions levels. The Transitional Green and Under-signalled Green phenotypes were characterised by low emissions across all GHG dimensions and high financial indicators (high ROA and ROE), demonstrating an efficient operating model with limited environmental impact. Meanwhile, the Aligned and Over-signalling phenotypes exhibited higher emissions. Notably, the financial performance of these two phenotypes differs: the Aligned phenotype exhibits low ROA and ROE ratios, potentially reflecting the cost of sustainability investments or a transition effect, while the Over-signalling phenotype exhibits high financial performance alongside high emissions. This combination suggests that higher financial capacity does not necessarily translate into lower environmental impacts or greater harmonisation of investments.

In summary, based on the results for the entire period analysed, phenotypes can be differentiated by environmental indicators, whereas statistical differences in financial indicators vary over time. The Aligned phenotype is not consistently associated with high financial or environmental performance across all time periods, whereas the Over-signalling phenotype is more often associated with higher emissions. Meanwhile, the Transitional Green and Under-signalled Green phenotypes present with more favourable combinations of emissions and financial outcomes over time, potentially indicating a more efficient business model or smaller-scale activities. Such results confirm that the sustainability behaviour of companies is heterogeneous and cannot be assessed solely based on signalling or investment indicators; therefore, the phenotype method provides an additional analytical approach to assessing the real patterns of companies' behaviour. Figure 6 presents the derived phenotype matrix, distinguishing the most recurrent environmental and financial characteristics associated with each phenotype.

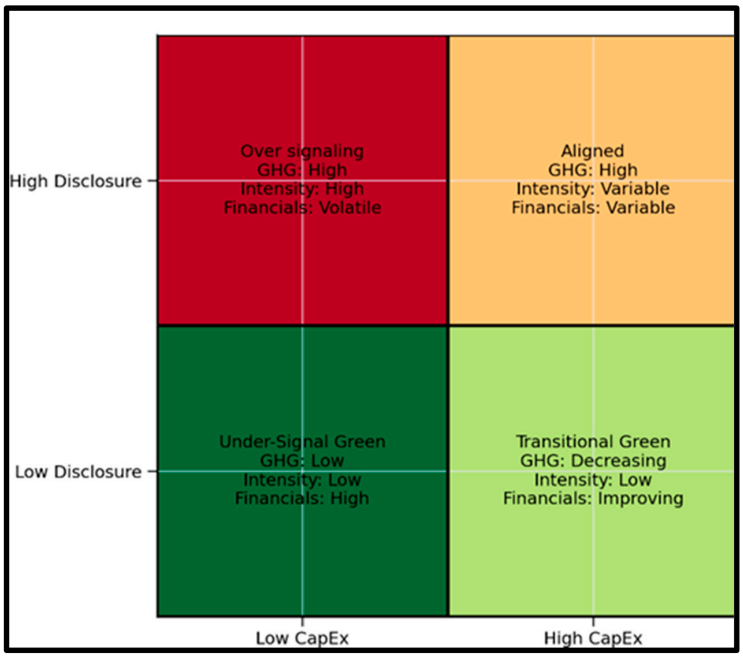

Figure 6. Matrix of Phenotypes. Note. Compiled by the author based on data from the Bloomberg database. In addition, Dark red = Over-signaling; light orange = Aligned; dark green = Under-signaling green; light green = Transitional green. The color scheme reflects the degree of alignment between environmental disclosure and green investment intensity.

In summary, the cluster analysis for the period 2022–2024 found that companies consistently redistribute into four main phenotypes, defined by environmental disclosures and CapEx investments: Under-signalled Green, Over-signalling, Transitional Green, and Aligned. The structure of phenotypes remains stable during the analysed period, but changes in their composition and heterogeneous transitions between clusters were observed, revealing the dynamic nature of enterprise adaptation. The key differentiation criterion remains the harmonised CapEx indicator, which most reliably indicates the compliance of investments with the requirements of the EU taxonomy. The results of the analysis also consistently confirm the existence of a disclosure–implementation gap: high scores for environmental disclosures do not necessarily imply a high level of investment compatibility, signalling a potential greenwashing risk. The phenotype analysis method provides an additional analytical basis that enables both the identification of distinct behavioural patterns and the evaluation of changes in those behaviours over time. This approach broadens the scope for sustainability assessment and provides a deeper understanding of companies' adaptation to environmental and taxonomic requirements. It can be concluded that a high level of disclosure does not in itself guarantee the effective implementation of sustainability principles, but that substantial progress depends on consistent investment decisions and their practical implementation. The proposed phenotype framework may serve as a practical tool for investors, regulators, and sustainability analysts by helping identify firms where sustainability disclosures are not fully supported by taxonomy-aligned investments. This may improve sustainability assessment, investment screening, and the identification of potential signalling–investment mismatches.

5. Conclusions

Based on the literature analysis, the environmental component is an essential part of the concept of sustainability, reflecting companies' environmental impact and enabling the evaluation of specific environmental outcomes. It has been found that the overall ESG score does not always accurately reflect the environmental content of a company's activities,

so analysing component E in isolation is important. It has been found that researchers measure environmental management using both quantitative indicators and ESG scores. This has allowed environmental investments to be identified as important for improving real performance.

That is, the literature demonstrates a positive bidirectional relationship between investments and environmental outcomes. In addition, it has been observed that overall investment levels do not always reflect companies' sustainability, with CapEx-eligible and CapEx-aligned criteria in the EU taxonomy being more appropriate.

In the literature, the misrepresentation of a green image is associated with incomplete disclosure, indicator distortion, symbolic initiatives, and differences in ESG ratings. Consequently, companies can create a strong environmental image that does not align with actual investments or performance. It has been found that an ESG E score often serves as a reputational signal that does not necessarily reflect the actual environmental impact. Therefore, the analysis of the E-score alone is not sufficient to identify a misleading green image.

The literature review further reveals that companies' environmental behaviour is closely linked to their financial capacity and cannot be assessed in isolation. Profitability, liquidity, capital structure, and indebtedness levels have been found to significantly affect companies' ability to invest in environmental initiatives. Financially stronger companies are more likely to make long-term sustainability investments, and financial constraints limit them. It has also been found that the relationship between environmental investments and financial performance is not unambiguous and depends on the sector, nature and time of the investment. Beyond financial factors, stakeholder pressure to drive sustainability initiatives plays an important role. However, because this pressure can lead to both real actions and symbolic sustainability communication, it is also necessary to evaluate actual investment decisions.

The theoretical analysis led to a classification of companies' phenotypes based on the combination of E-score and CapEx indicators. This classification provided insight into the distinction between declared signals and actual investments, with four phenotypes developed to reflect the behaviour of companies in the context of sustainability: Under-Signalled Green, Over-signalling, Transitional Green, and Aligned.

The expert survey showed sufficient consensus (W = 0.72) and enabled the identification of the main financial and environmental indicators used to analyse phenotypes. In the financial dimension, the most important indicators were profitability, efficiency, liquidity, and capital structure (e.g., ROA, ROE, net profitability), while the environmental dimension focused on GHG emissions and their intensity. The expert survey confirmed that in the analysis of phenotypes, it is important to evaluate not only the signalling or investment dimensions, but also the specific financial and environmental characteristics, which allow for describing the content of each phenotype in more detail.

An empirical assessment of statistical differences between phenotypes using the Kruskal–Wallis test showed that the phenotypes of enterprises, based on environmental disclosures and CapEx indicators, differ statistically significantly for most environmental indicators. For all the years analysed—2022, 2023, and 2024—significant differences were identified in GHG emission intensity, Scope 1, Scope 2 (location-based), Scope 2 (market-based), and Scope 3 emissions. This suggests that phenotypes are not just a theoretical or conceptual classification—they reflect real and statistically significant differences in the environmental impact of companies. In terms of financial indicators, the most stable differences between phenotypes were determined by ROA and ROE, with these indicators differing statistically significantly throughout the study year. This shows that different patterns of environmental behaviour are also related to differences in the financial efficiency

of companies. Meanwhile, the differences between net profitability, current liquidity, and ROA and ROE ratios were less stable over time. Differences in net profitability are material only in 2022, current liquidity only in 2023, and capital structure indicators were mostly marginal. Therefore, it can be said that differences in financial characteristics exist between phenotypes, but their stability is lower than that of environmental indicators. Analysis of phenotypic characteristics showed that the Over-signalling phenotype is more often associated with higher emissions and a mismatch between disclosure and real investments, and can therefore be interpreted as a higher-risk group for misleading green messaging. The Aligned phenotype is characterised by a more favourable alignment of investments in some periods, but its financial and environmental results are not unequivocally the best throughout the year. The Transitional Green and Under-Signalled Green phenotypes exhibit more favourable combinations of emissions and financial results over time, but their interpretation depends on the specific time period and activity scale. These results confirm that companies' sustainability behaviour is heterogeneous and dynamic and cannot be measured solely by ESG signals or investment indicators. Additionally, the results further demonstrate that CapEx-eligible and CapEx-aligned investments capture different stages of corporate sustainability transition. While eligible CapEx reflects firms' capacity and intention to participate in Taxonomy-covered activities, aligned CapEx provides evidence of actual compliance with the EU Taxonomy framework. Therefore, the interpretation of greenwashing risks should primarily focus on discrepancies involving aligned CapEx rather than eligibility measures alone. In summary, the results of the Kruskal–Wallis test confirmed the empirical validity of the phenotype classification: different phenotypes differ significantly in terms of environmental indicators and aspects of financial indicators, meaning that this classification can be used as a practical diagnostic tool for assessing the sustainability behaviour of companies, the compatibility of real investments with the EU taxonomy, and the potential risk of greenwashing.

Limitations and Recommendations

This study's findings are subject to several limitations. The analysis is limited to European listed companies included in the Bloomberg database and covers only the 2022–2024 period. In addition, environmental scores depend on Bloomberg's methodology. Furthermore, EU Taxonomy reporting requirements continue to evolve, potentially affecting the future stability and interpretation of the identified phenotypes. Additionally, the results may not be generalisable to privately held firms or to companies operating outside the European regulatory environment. Future studies could employ alternative ESG databases and examine longer observation periods.

Future research could complement the analysis by applying post hoc pairwise comparison procedures and effect size measures to provide a more detailed assessment of the magnitude and direction of differences among individual sustainability phenotypes. Such extensions would further strengthen the statistical interpretation and robustness of the proposed classification framework.

Author Contributions: Conceptualization, O.P. and R.S.; methodology, O.P. and R.S.; formal analysis, O.P. and R.S.; investigation, O.P. and R.S.; data curation, O.P. and R.S.; writing—original draft preparation, O.P. and R.S.; writing—review and editing, O.P. and R.S.; supervision, R.S. All authors have read and agreed to the published version of the manuscript.

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Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki, and approved by the Ethics Committee of Vilnius University (protocol code: 5.1.28 Mr-10000-KT-1133 on 27 March 2026).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: The data supporting the findings of this study were derived from Bloomberg. The processed dataset generated during the current study is available from the corresponding author upon reasonable request.

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A. List of Companies Analysed

Short Name of the Co.			
CORTICEIRA AMORI	SCANIA CV AB	ALTAREIT	DNA OY
CRH PLC	NEWPRINCES SPA	IBERSOL SGPS SA	FLATEXDEGIRO SE
KION GROUP AG	MARIE BRIZARD WI	WASHTEC AG	ENIRO GROUP AB
BOLIDEN AB	INAPA	BONAVA AB	PETRO WELT TECHN
DR ING HC F PORS	ESSILORLUXOTTICA	LEIFHEIT AG	MEDICOVER AB-B
ALRO SA	STORSKOGEN GRO-B	ELMOS SEMICONDUC	BETER BED HLDG
SIEMENS GAMESA R	NORTHVOLT AB	IONOS GROUP SE	HOME24 SE
DSM-FIRMENICH AG	ZE PAK SA	TEIXEIRA DUARTE	COMP
TITAN SA	KRKA	ADDTECH AB-B SH	BOUVET ASA
TENARIS SA	ASTARTA	SUBSEA 7 SA	CENTRUM MEDYCZNE
ERICSSON LM-B	BULTEN AB	AIXTRON SE	EXOR NV
SHELL PLC	ARJO AB - B	EYDAP WATER	KINDRED GROUP PL
UNILEVER PLC	NEDERMAN HOLDING	ADTRAN NETW SE	ALUMETAL SA
STELLANTIS NV	AGORA	DEMANT A/S	DYNAVOX GROUP AB
DAIMLER TRUCK HO	MYCRONIC AB	ITAB SHOP	STALPROFI
NORDEX SE	BOIRON SA	BILIA AB-A SHS	AUTOHELLAS SA
ORSTED A/S	CHRISTIAN DIOR	SECUNET SECURIT	TECHNOTRANS SE
SAAB AB-B	KATEK SE	ELANDERS AB-B	CLAS OHLSON-B SH
RAWLPLUG SA	NEINOR HOMES SA	KLOECKNER & CO S	ATRYS HEALTH SA
KGHM	NOBIA AB	ERICSSON NIKOLA	BYGGMAX GROUP AB
FRESENIUS SE & C	ESPRINET SPA	WAWEL	FRIWO AG
AGFA-GEVAERT NV	SWEDISH ORPHAN B	WASTBYGG GRUPPEN	LEONI AG
SMURFIT KAPPA GR	AKOLA GROUP AB	EXCLUSIVE NETWOR	UNIPHAR PLC
ASM INTL NV	FAGERHULT GROUP	MANGATA HOLDING	ENEA AB
MICHELIN	VITESCO TECHNOLO	UIE PLC	TROAX GROUP AB
ALFA LAVAL AB	REDCARE PHARMACY	NORTH MEDIA AS	AHLSELL DANMARK
BMW AG	QUADIENT SA	ABOUT YOU HOLDIN	MATAS A/S
GREENYARD NV	ALTAREA	AVAX SA	KINEPOLIS
GRUPA AZOTY SA	SP GROUP A/S	EPENDION AB	PROACT IT GROUP
HIAB OYJ	VOLVO AB-B	BAJAJ MOBILITY A	AS MERKO EHITUS
D'AMICO INTERNAT	JOHANSEN A&O-B	FUCHS SE	GABRIEL HLDG
VICAT	COGNOR	JENOPTIK AG	HYPOPORT SE
ALLEIMA AB	PIRAEUS PORT AUT	KOENIG & BAUER	BALLYS INTRALOT
ATRIA OYJ	VOSSLOH AG	BALCO GROUP AB	FINATIS SA
MOTOR OIL-HELLAS	PETROL DD LJUBLJ	ADDLIFE AB-B	BE GROUP AB
GLANBIA PLC	SAF-HOLLAND SE	PURMO GROUP OYJ	GALAPAGOS NV
ARCTIC	TESSENDERLO GROU	ASBIS	PCC ROKITA SA
RENAULT SA	ERBUD	LUBAWA SA	ROCHE BOBOIS SA
SCHNEIDER ELECTR	ALIMAK GROUP	IMPRESA SGPS SA	BONHEUR ASA
TAURONPE	BENEFIT	JACQUET METALS S	MEDSERV PLC
NILFISK HOLDING	SBO AG	EUTELSAT COMMUNI	LOGWIN AG
NIBE INDUSTRIE-B	ALLEGRO.EU SA	TOMTOM NV	SCHWEIZER ELECTR
GEOX SPA	PST GROUP	SELENAFM	PVA TEPLA AG
LUOSSAVAARA-KIIR	LAMPSA HOTEL CO	PROFILGRUPPEN-B	KEYSIGHT TECHNOL
WIENERBERGER AG	KEMPOWER OYJ	CAFOM SA	AQUILA PART PROD
BIOMERIEUX	BASLER AG	GO PLC	CTS EVENTIM AG &
NOVONESIS (NOVOZ	WACKER NEUSON SE	DEBICA	BRUNEL INTL
BEFESA SA	VALNEVA SE	Q BEYOND AG KONV	OT LOGISTICS SA
LIFCO AB-B	TELIA LIETUVA AB	BASICNET SPA	BONG AB
TRATON SE	INTERCOS SPA	ACOMO NV	AUMANN AG
HARJU ELEKTER	AXFOOD AB	MT HOJGAARD HOLD	KHD HUMBOLDT WED
BUDIMEX	BE SEMICONDUCTOR	VILLEROY & BOC-P	GRUPO MEDIA CAP
CSP INTERNATIONA	LAGERCRANTZ-B SH	TRIFORK GROUP AG	SYZYGY AG
SYMRISE AG	POZNANSKA KORPOR	MOSTALZAB	DECORA
FRESENIUS MEDICA	VIRBAC SA	NOTE AB	INIT INNOVATION
ENEXIS HOLDING B	HARBOES BRYGGE-B	TECHNICOLOR CREA	CHERRY SE
KONINKLIJKE PHIL	ISS GLOBAL A/S	SPACE HELLAS SA	NNIT A/S
AB GRIGEO	VRG SA	AZELIS GROUP NV	AUTO1 GROUP SE
KONINKLIJKE AHOL	BAVARIAN NORDIC	CAREIUM AB	NORDECON AS
OLVI OYJ-A SHS	HAULOTTE GROUP	BORYSZEW	FM MATTSSON AB
APATOR	LECTRA	HUSCIET A/S	EKSPRESS GRUPP A
DEKPOL SA	DECEUNINCK NV	HENSOLDT AG	COLUMBUS A/S
TELEFONICA	MANITOU BF	KOFOLA CESKOSLOV	BANQUP GROUP
ORSERO SPA	B&S GROUP SARL	FDJ UNITED	GROUPE SFPI
FAMUR	NEUCA	IVU TRAFFIC TECH	UTENOS TRIKOTAZA
AMICA	UNIBEP	BRAVIDA HOLDING	SEMCON AB
BOGDANKA	DOMETIC GROUP AB	MULTICONSULT ASA	INTRUM AB
PODRAVKA PREHRAM	ONDE SA	MODERN TIMES-B	ARAMIS GROUP SAS
KAUFMAN & BROAD	NEWAG SA	WIELTON	MOMENTUM GROUP K
LAMDA DEVELOPMEN	TOBII AB	SANOK RUBBER CO	FOURLIS SA
DIASORIN SPA	QUEST HOLDINGS	WABERER'S INTERN	AZERION GROUP NV
COLOPLAST-B	MELEXIS NV	MAKING SCIENCE G	SHOWROOMPRIVE
UPONOR OYJ	FORFARMERS NV	TORPOL SA	SYNERGON HOLDING
ROKISKIO SURIS	SIPEF NV	INTL HOTEL INV	MORPHOSYS AG
NOKIA OYJ	ELIA GROUP SA/NV	AKTOR SA HOLDING	KABE GROUP AB-B
ALUMIL ALUMINIUM	IDEAL HOLDINGS	1&1 AG	PUUILO OYJ
ATHENS MEDICAL	HYDRATEC INDUSTR	FERRO	AMADEUS FIRE AG
SAES GETTERS SPA	LOOMIS AB	FLUEGGER GROUP	ASSECOBS
DHL GROUP	HELLOFRESH SE	NILORNGRUPPEN-B	BASSAC SA
STALPROD	AUGA GROUP AB	SECOGROUP	BULGARIAN ENERGY
BIC	ARGENX SE	UNITED INTERN-RE	G5 ENTERTAINMENT
ASML HOLDING NV	LATOUR INV-B	EUROCASH	LEOVEGAS AB
HKFOODS OYJ	VILKYSKIU PIENIN	NEW WAVE GROUP-B	MELTWATER HOLDIN
FAES FARMA	TALLINK GRUPP	BHG GROUP AB	TURBON AG
APPLUS SERVICES	KARELIA TOBACCO	ABPL	RODNA ZEMYA HOLD
ALK-ABELLO A/S	CASINO GUICHARD	ZUE SA	KEDRION SPA
DURO FELGUERA SA	PALFINGER AG	ATOSS SOFTWARE	KGL SA
HENNES & MAURI-B	INTERPUMP SPA	ASSECOPOL	PLASTIKA KRITIS
SARANTIS	GRAINES VOLTZ SA	BETTER COLLECTIV	
SERGE FERRARI GR	H+H INTL A/S-B	MOSTALWAR	
RATIONAL AG	STROEER SE & CO	CRITERIA CAIXA S	
IMCD NV	NORGESGRUPPEN AS	INTERCARS	
LABORATORIOS FAR	NETCOMPANY GROUP	AUTO PARTNER SA	
JUMBO SA	XANO INDUSTRI -B	FERRONORDIC AB	
SEMAPA	SUSS MICROTEC SE	SLIGRO FOOD GROU	
ATLAS COPCO-A	DINO POLSKA SA	VIOHALCO SA	
SARTORIUS AG	STEDIN HOLDING N	OPENJOBMETIS SPA	
TKM GRUPP AS	ASSECOSEE	GRUPA KAPITALOWA	
SNIEZKA	BURELLE SA	HOMETOGO SE	

Note. Compiled by the author based on data from the Bloomberg database.

Appendix B. Financial Position and Environmental Management Indicators

Type	Indicator	Formula/Description
Profitability	Net profitability Net Profit Margin	Net profit/Sales revenue
Profitability	Gross profit margin Gross Margin	Gross profit/Sales revenue
Profitability	Operating margin Operating Margin	EBIT/Sales Revenue
Profitability	EBITDA margin	EBITDA/Sales Revenue
Profitability	ROA Return on Assets	Net Profit/Average Assets (or NOPAT/Average Assets)
Profitability	ROE Return on Equity	Net profit/Equity
Liquidity	Current liquidity ratio	Current assets/Current liabilities
Liquidity	Quick Ratio	(Current assets—Stocks)/Current liabilities
Liquidity	Cash Ratio	(Cash + Trump. investment)/Trump. Commitments
Liquidity	Net Working Capital	Current assets—Current liabilities
Liquidity	Working capital ratio	NWC/Sales Revenue
Leverage	Debt ratio	All Liabilities/Assets
Leverage	Debt to Equity Ratio	Total Liabilities/Equity
Leverage	Equity ratio	Equity/Assets
Leverage	Capitalisation of long-term debt	Long-term debt/(Long-term debt + Equity)
Leverage	Net debt Net Debt	Interest-bearing debts—Cash
Leverage	Net debt/EBITDA	Net debt/EBITDA
Leverage	Altman Z-score	
Leverage	DSCR Debt Service Coverage	(Operating Cash Flow + Interest)/(Interest + Principal Repayment)
Operational efficiency	Turnover of assets Asset Turnover	Sales Revenue/Average Assets
Operational efficiency	Fixed asset turnover	Sales Revenue/Average Fixed Assets
Operational efficiency	Turnover of current assets	Selling Cost/Average Current Assets
Operational efficiency	Receivables turnover	Sales Revenue/Receivables
Operational efficiency	Turnover payable	Sales cost/Accounts payable

ESRS Area	Type of Quantitative Indicators
ESRS E1—Climate change	GHG emissions (1, 2, 3 and total) (tonnes CO_2 eq) GHG emission intensity (tCO_2e per unit of revenue) Energy consumption and mix of energy sources (MWh, % of renewables) GHG removals and carbon credits (tonnes of CO_2 eq) Estimated financial impact in terms of climate risks/opportunities (EUR)
ESRS E2—Pollution	Microplastic content (kg or t) Pollutant emissions to air, water, soil (tonnes) Use of 'substances of concern' (tonnes) Substances of very high concern (SVHCs) (tonnes) Estimated financial impact on pollution risks/opportunities (EUR)

ESRS Area	Type of Quantitative Indicators
ESRS E3—Water resources	Total water consumption (m^3) Water consumption in risk areas (m^3) Reused and recycled water (m^3) Change in accumulated water (m^3) Water intensity (m^3/product unit or €) Estimated financial impact on water risks/opportunities (EUR)
ESRS E4—Biodiversity	Objects in biodiversity-sensitive areas (number and ha) Other biodiversity impact indicators (if applicable) Estimated financial impact on biodiversity risks/opportunities (EUR)
ESRS E5—Circular Economy	Resource inputs: amount of materials used (tonnes) Inputs: Use of secondary raw materials (tonnes, %) Inputs: sustainable share of biological materials (%) Resource outputs: product circularity indicators (% recyclable, durability) Resource outputs: quantity and management of waste (tonnes) Estimated financial impact on the risks and opportunities of resource use (EUR)

Note. Compiled based on the following research papers: European Commission (2023a, 2023b, 2023c); EFRAG (2023); Deloof (2003); Fu and Jacobs (2022); Cohen (2023); Oestreich and Tsiakas (2024); Quintiliani (2024); Zhang et al. (2025); Del Sarto (2025); Pérez Estébanez and Sevillano Martín (2025); Arhinful and Radmehr (2023).

Appendix C. Expert Survey

My name is Odeta Pileckaitė, and I am a PhD student in management at the Faculty of Economics and Business Administration, Vilnius University. I am currently conducting academic research to develop an integrated system of environmental and financial management indicators that enables a comprehensive assessment of organisational performance in the context of sustainability. The research seeks to identify which environmental indicators are most significant for financial management decision-making and how to integrate them into corporate performance evaluation and strategic planning. This survey is an important part of my research and helps collect the valuable data necessary to achieve this objective.

I would like to emphasise that all data collected during the survey will be anonymous. The data will be collected in accordance with the principles of fairness, integrity, and other ethical standards. The anonymised data will be stored in the author's cloud storage at Vilnius University.

Please also note that participants have the right to withdraw from the study at any stage of the research process. Participation in this survey is entirely voluntary, and we sincerely appreciate the time you devote and your contribution to this research.

Please indicate whether you agree to participate in the survey presented below: Agree Disagree.

Thank you for your response and participation. If you agree to take part in the survey, the questions are provided below.

We kindly ask you to evaluate the importance of the indicators presented below in the context of environmental protection and sustainability, on a scale from 1 (not important at all) to 7 (extremely important).

Rodiklio tipas (Ratio type)	Rodiklio pavadinimas (Ratio name)	Balas (Score)						
		1	2	3	4	5	6	7
		Visiškai nesvarbus (Not important at all)	Labiau nesvarbus (Rather unimportant)	Šiek tiek nesvarbus (Somewhat unimportant)	Nei svarbus, nei nesvarbus (Neither important nor unimportant)	Šiek tiek svarbus (Somewhat important)	Labiau svarbus (Rather important)	Visiškai svarbus (Extremely important)
Pelningumas (Profitability)								
	Grynasis pelningumas (Net Profit Margin)							
	Bendrojo pelno marža (Gross Margin)							
	Operacinė marža (Operating Margin)							
	EBITDA marža (EBITDA Margin)							
	ROA (Return on Assets)							
	ROE (Return on Equity)							
Likvidumas (Liquidity)								
	Einamasis likvidumo koef. (Current Ratio)							
	Skubusis likvidumo koef. (Quick Ratio)							
	Pinigų likvidumo koef. (Cash Ratio)							
	Grynasis apyvartinis kapitalas (Net Working Capital – NWC)							
	Apyvartinio kapitalo santykis (Working Capital Ratio)							
Finansinis svertas (Financial leverage)								
	Įsiskolinimo koeficientas (Debt Ratio)							
	Skolos / nuosavo kapitalo (Debt to Equity)							
	Nuosavo kapitalo santykis (Equity Ratio)							
	Ilgalaikės skolos kapitalizacija (Long-Term Debt to Capitalization Ratio)							
	Grynoji skola (Net Debt)							
	Grynoji skola / EBITDA (Net Debt / EBITDA)							
	Sudėtinis bankroto rizikos indeksas (pagal Altman formulę) (Altman Z-score)							
	DSCR (Skolų aptarnavimo dengimo rodiklis) (Debt Service Coverage Ratio)							
Veiklos efektyvumas (Efficiency Ratio)								
	Turto apyvartumas (Asset Efficiency Ratio)							
	Ilgalaikio turto apyvartumas (Fixed Asset Efficiency Ratio)							
	Trumpalaiko turto apyvartumas (Inventory Efficiency Ratio)							
	Gautinų apyvartumas (Receivables Efficiency Ratio)							
	Mokėtinų apyvartumas (Payables Efficiency Ratio)							
ESRS E1 – Klimato kaita (ESRS E1 – Climate change)								
	ESD emisijos (1, 2, 3 ir viso) (GHG Emissions – Scope 1, 2, 3 and Total) (tCO_2e)							
	ŠESD emisijų intensyvumas (GHG Emission Intensity – tCO_2e per revenue unit)							
	Energijos sunaudojimas ir energijos šaltinių miksas (Energy Consumption and Energy Mix – MWh, % renewable)							
	ŠESD absorbavimas ir anglies kreditai (GHG Removals and Carbon Credits – tCO_2e)							
	Numatomas finansinis poveikis klimato rizikų/galimybių (Expected Financial Impact of Climate Risks/Opportunities – EUR)							
ESRS E2 – Tarša (ESRS E2 – Pollution)								
	Mikroplastikų kiekis (Microplastics Quantity – kg or t)							
	Teršalų išmetimai į orą, vandenį, dirvožemį (Pollutant Emissions to Air, Water and Soil – tonnes)							
	„Susirūpinimą keliančių medžiagų" naudojimas (Use of Substances of Concern – tonnes)							
	Labai didelį susirūpinimą keliančios medžiagos (SVHC) (Substances of Very High Concern – SVHC – tonnes)							
	Numatomas finansinis poveikis taršos rizikų/galimybių (Expected Financial Impact of Pollution-Related Risks/Opportunities – EUR)							
ESRS E3 – Vandens ištekliai (ESRS E3 – Water and marine resources)								
	Bendras vandens suvartojimas (m^3) (Total Water Consumption – m^3)							
	Vandens suvartojimas rizikos zonose (m^3) (Water Consumption in Water-Stress Areas – m^3)							
	Pakartotinai panaudotas ir perdirbtas vanduo (m^3) (Reused and Recycled Water – m^3)							
	Sukaupto vandens pokytis (m^3) (Change in Stored Water – m^3)							
	Vandens naudojimo intensyvumas (m^3/produkto vnt. ar €) (Water Use Intensity – m^3 per product unit or per €)							
	Numatomas finansinis poveikis vandens rizikų/galimybių (EUR) (Expected Financial Impact of Water-Related Risks/Opportunities – EUR)							
ESRS E4 – Biologinė įvairovė (ESRS E4 – Biodiversity and ecosystems)								
	Objektai bioįvairovei jautriose teritorijose (skaičius ir ha) (Sites in Biodiversity-Sensitive Areas – number and ha)							
	Numatomas finansinis poveikis bioįvairovės rizikų/galimybių (EUR) (Expected Financial Impact of Biodiversity-Related Risks/Opportunities – EUR)							
ESRS E5 – Žiedinė ekonomika (ESRS E5 – Resource use and circular economy)								
	Išteklių įvediniai: sunaudotų medžiagų kiekis (tonomis) (Resource Inputs: Quantity of Materials Used – tonnes)							
	Išteklių įvediniai: antrinių žaliavų naudojimas (tonomis, %) (Resource Inputs: Use of Secondary Raw Materials – tonnes, %)							
	Išteklių įvediniai: tvari biologinių medžiagų dalis (%) (Resource Inputs: Share of Sustainable Biobased Materials – %)							
	Išteklių išvediniai: gaminių žiediškumo rodikliai (% perdirb., patvarumas) (Resource Outputs: Product Circularity Indicators – % recycled, durability)							
	Išteklių išvediniai: atliekų kiekis ir tvarkymas (tonomis) (Resource Outputs: Waste Generation and Treatment – tonnes)							
	Numatomas finansinis poveikis išteklių naudojimo rizikų/galimybių (EUR) (Expected Financial Impact of Resource-Use-Related Risks/Opportunities – EUR)							

Figure A1. Expert Survey.

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