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Industry Differences in ESG Risk: An Analysis Using Morningstar Sustainalytics Data

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Abstract: Environmental, social and governance factors have become increasingly important for investors, businesses and policymakers, particularly in the context of reducing information asymmetry and promoting sustainable business models. The study analysed differences in the level of environmental, social and governance risk across industries, ranked them by risk level and identified groups of industries with similar levels of risk. The aim of the study was to statistically verify the existence of differences across industries, with the aim of contributing to a better understanding of the distribution of risk across industries and supporting informed decision-making by relevant actors. The analysis was based on a database containing data on the risk level of 13,355 companies operating in 41 industries of the global economy. The data were obtained from the Morningstar Sustainalytics database. Non-parametric statistical methods were used to verify differences across industries. The robustness of the identified grouping structure was additionally verified using hierarchical cluster analysis. The results of pairwise comparisons showed statistically significant differences across industries. Based on these findings, industries were systematically arranged into nine groups according to risk level, from lowest to highest risk. The results provided a clear classification of industries and highlighted the existence of significant differences in risk levels across industries.

Keywords: ESG risk, industry differences, industry risk analysis, Morningstar Sustainalytics, risk ranking.

JEL classification: G32, L00, M14, Q56

Introduction

Environmental, social, and governance (ESG) factors have played an increasingly important role in the financial sector and corporate sphere in recent years, particularly in relation to reducing information asymmetry and promoting sustainable business models (Panko & Glova 2024). ESG risks have gradually become a significant component of firms' overall risk profiles, with their nature and intensity determined by industry-specific characteristics and business activities (Zioło et al. 2023). The growing importance of these factors has led to the development of various methodologies for their measurement and evaluation, enabling the quantification of non-financial aspects of corporate performance and resilience to risk (Koundouri et al. 2022).

Despite the extensive body of research on ESG assessment, several limitations persist. Existing studies have primarily focused on the relationship between ESG factors and financial performance or on comparisons of rating methodologies across different agencies. However, a systematic comparison of ESG risk levels across industries and their subsequent classification remains insufficiently explored. Moreover, differences in assessment methodologies result in divergent outcomes, which complicates the interpretation and practical applicability of environmental, social, and governance information in decision-making processes (Wanday & Zein 2022).

The aim of the article was to identify and statistically verify differences in ESG risk levels across industries, to establish an industry ranking based on risk levels, and to identify groups of industries with similar levels of risk. The purpose of the article was to contribute to a better understanding of the distribution of ESG risk across industries and to support informed decision-making by investors, managers, and policymakers. The added value of the research lies in the systematic classification of industries based on ESG risk levels, enabling a more comprehensive comparison of risk profiles across industries. Unlike previous studies focusing primarily on the relationship between ESG performance and financial outcomes, this study contributes to the literature by providing a large-scale empirical classification of industries according to ESG risk exposure and by identifying statistically significant boundaries between industry risk groups.

The analysis was based on environmental, social, and governance risk data for 13,355 companies operating across 41 industries in the global economy, obtained from the Morningstar Sustainalytics database. The ESG Risk Ratings methodology developed by Morningstar Sustainalytics constitutes an analytical framework for assessing the level of unmanaged risk associated with environmental, social, and governance factors and ensures the comparability of results across firms and industries (Morningstar 2025). Non-parametric statistical methods were employed to test differences between industries, specifically the Kruskal–Wallis test and pairwise comparisons using the Mann–Whitney test. These methods made it possible to identify statistically significant differences and subsequently construct homogeneous groups of industries according to ESG risk levels.

The introductory section defines the importance of the research topic, identifies existing research gaps, and formulates the aim, purpose, and contribution of the study. The second section provides an overview of relevant empirical studies and outlines the main research approaches and their limitations. The third section describes the research methodology, data characteristics, and analytical procedures. The fourth section presents the results of the analysis and their discussion. The final section summarizes the main findings and highlights their practical implications.

1 Literature Review

Given the inconsistency in the assessment of environmental, social, and governance factors, it is essential to systematically synthesize existing research addressing various aspects of ESG evaluation. A substantial body of the literature focuses on identifying the causes of divergence among ESG ratings provided by different agencies. Studies indicate that discrepancies in ratings are not primarily driven by data availability, but rather by differences in measurement methodologies, weighting schemes, and data aggregation processes (Christensen et al. 2021, Şahin et al. 2022). This inconsistency significantly reduces the comparability of results and complicates their interpretation in investment decision-making (Shi & Yao 2025, Liu 2022). The divergence of ESG ratings also has important implications for investor behavior and financial markets. Empirical studies suggest that a high level of disagreement among ratings may lead investors to disregard them or reduce their confidence in these indicators (Bissoondoyal-Bheenick et al. 2024). The low correlation between ratings from different providers therefore represents a challenge for both regulators and investors, as it calls into question their reliability as tools for risk assessment (Swinkels & Markwat 2023). In response to these issues, the need for harmonization of methodologies and regulatory frameworks has been emphasized, particularly within the European Union, where initiatives aimed at enhancing the transparency and quality of ESG data are being implemented (Búa et al. 2023).

Another important stream of research focuses on the concept of ESG materiality, which highlights that not all environmental, social, and governance factors are equally relevant across industries. According to Khan et al. (2015), ESG factors that are financially material to a given industry have the greatest impact on firm value, and investments in such factors are associated with improved corporate performance. In contrast, non-material ESG activities do not demonstrate a significant effect on financial outcomes. Building on these findings, Grewal et al. (2021) emphasize the importance of disclosing material ESG information, showing that transparency in this area enhances stock price informativeness and improves market efficiency. The literature increasingly highlights the importance of industry differences in ESG risk. Several studies confirm that both the level of ESG risk and its impact on financial performance vary significantly across industries (Hinsche & Klump 2023, Yang et al. 2024, Miloș & Laura 2025). Industries with high environmental exposure, such as energy and extractive industries, tend to exhibit higher levels of ESG risk, whereas industries with lower environmental impact generally display lower risk profiles. At the same time, the relationship between ESG performance and financial outcomes is not homogeneous and depends on the specific characteristics of individual industries (Zaiane et al. 2025).

Despite these insights, a systematic classification of industries based on ESG risk levels remains relatively underdeveloped. Existing studies predominantly focus either on the materiality of ESG factors or on their impact on financial performance, while less attention has been devoted to a comprehensive comparison of risk profiles across industries and their subsequent typology. This gap provides the foundation for the present research, which aims to identify differences in ESG risk levels across industries and to develop their systematic classification.

The present study builds on the existing literature by combining an industry perspective with a quantitative assessment of ESG risk based on Morningstar Sustainalytics data and extends prior research through the systematic ordering of industries according to their risk levels. In doing so, it contributes to a deeper understanding of industry differences in ESG risk and complements existing research on ESG materiality and its financial implications.

2 Methodology

The aim of this paper is to examine and quantify the relationship between ESG risk values and the industry affiliation of companies, with a particular focus on identifying industries characterized by similar ESG risk profiles. The analysis is based on the Morningstar Sustainalytics database, which is considered one of the leading global providers of ESG ratings and is recognized for its comprehensive approach to assessing environmental, social, and governance risks.

The dataset was compiled through a systematic collection of data during August 2025 using the publicly accessible Morningstar Sustainalytics database. Subsequently, public access to these data was restricted, which increases the uniqueness and research value of the obtained dataset. The final dataset contains information on ESG risk ratings and industry affiliation for a total of 13,355 companies operating across 41 industries worldwide. Since the dataset included all publicly available information accessible from the selected source at the time of data collection, it can be considered sufficiently extensive and broadly representative for the purposes of the

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analysis, despite the inability to verify exact representativeness due to the absence of comprehensive information on the total number of firms operating within individual industries globally.

Although ESG ratings provided by different agencies may diverge due to methodological differences, Morningstar Sustainalytics was selected because it offers one of the most comprehensive publicly available ESG risk datasets and applies a transparent methodology focused explicitly on unmanaged ESG risk. Nevertheless, the results should be interpreted within the context of this specific rating framework.

The ESG Risk Rating developed by Sustainalytics reflects the degree of a company's exposure to environmental, social, and governance risks together with its ability to effectively manage these risks. The rating is based on a combination of indicators capturing material ESG factors relevant to a specific industry. Higher ESG risk ratings indicate a higher level of unmanaged ESG risk. However, the interpretation of ESG ratings should consider several potential sources of bias, including differences in regulatory frameworks, legislative environments, levels of corporate transparency, and country-specific conditions. Furthermore, ESG ratings represent dynamic indicators that may change over time depending on developments in corporate policies, disclosure practices, and regulatory requirements, which may also influence the comparability of results.

The analysis employed descriptive statistical methods together with non-parametric statistical tests. Descriptive statistics included the calculation of means, medians, standard deviations, and minimum and maximum ESG risk values across individual industries. To identify differences among multiple independent groups, the Kruskal–Wallis test (H_0: $F_1(x) = F_2(x) = \cdots = F_k(x)$, H_1: $\exists\, i, j$: $F_i(x) \neq F_j(x)$) was applied, allowing for the comparison of industries without requiring the assumption of normally distributed data. Subsequently, the Mann–Whitney U test (H_0: $F_1(x) = F_2(x)$, H_1: $F_1(x) \neq F_2(x)$) was used to assess statistically significant differences between selected groups of industries.

The use of non-parametric methods was intentional, as the ESG risk variable did not exhibit a normal distribution across all analysed industries, which was confirmed through normality testing using the Shapiro–Wilk test (H_0: $X \sim N(\mu, \sigma^2)$, H_1: $X \nsim N(\mu, \sigma^2)$). In addition, not all assumptions required for the application of parametric tests, particularly homogeneity of variances and exact sample representativeness, were verified. Given the nature and size of the dataset, as well as the potential presence of outliers and unequal group sizes across industries, non-parametric tests represent a more robust and methodologically appropriate approach for the analysis of the examined issue. All hypotheses regarding differences in central tendency were tested at the standard significance level of $\alpha = 0.05$, ensuring an adequate level of reliability of the obtained results.

To assess the robustness of the identified industry groups, an additional hierarchical cluster analysis using the Average Linkage method was performed. The cluster analysis was based on average ESG risk values for individual industries and served as a supplementary tool for verifying the consistency of the grouping structure obtained through the Kruskal–Wallis and Mann–Whitney tests.

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3 Results and Discussion

3.1 Descriptive Statistics

Table 1 presents the descriptive statistics of the analysed dataset, which consists of ESG risk rating calculated by Morningstar Sustainalytics using its proprietary ESG risk assessment model. The table groups companies according to their industry affiliation and reports the percentage representation of individual industries within the total number of analysed firms (%), the mean ESG risk rating (Mean), standard deviation (Std. Dev.), minimum and maximum ESG risk values, as well as the results of the Shapiro–Wilk normality test. These indicators provide a comprehensive overview of the structure of the dataset, together with the variability and distribution of ESG risk across industries.

Table 1: Descriptive Statistics of ESG Risk Ratings Across Industries, Tests of Normality

Industry	%	Mean	Std. Dev.	Min.	Max.	Shapiro-Wilk		
						Statistic	df	Sig.
Aerospace & Defense	0.67%	36.15	7.77	21.00	52.30	.979	90	.146
Auto Components	1.72%	23.01	6.30	6.00	38.00	.992	230	.234
Automobiles	0.60%	26.41	7.63	8.70	43.40	.975	80	.116
Banks	7.40%	24.83	7.54	4.00	41.00	.973	988	.000
Building Products	0.99%	26.26	5.53	10.00	40.00	.989	132	.371
Construction & Engineering	2.35%	38.47	8.17	12.30	57.80	.990	314	.032
Construction Materials	0.82%	33.27	6.83	18.00	47.00	.981	110	.127
Consumer Durables	1.43%	20.06	6.98	7.00	39.00	.970	191	.000
Consumer Services	3.00%	24.79	7.84	7.00	40.00	.954	400	.000
Containers & Packaging	0.55%	18.54	4.76	8.00	29.00	.983	74	.441
Diversified Financial	5.43%	25.80	7.22	4.20	45.10	.990	725	.000
Diversified Metals	1.56%	42.07	10.95	7.70	65.50	.968	209	.000
Electrical Equipment	2.12%	27.91	5.82	9.30	44.50	.984	283	.003
Energy Services	0.70%	27.41	5.71	14.40	40.20	.986	94	.417
Food Products	3.86%	33.58	7.91	16.40	55.10	.991	516	.002
Food Retailers	1.27%	24.27	5.22	13.20	41.10	.991	169	.396
Healthcare	3.92%	25.24	6.82	7.40	39.80	.979	523	.000
Homebuilders	0.52%	22.29	5.59	11.80	36.40	.969	70	.078
Household Products	0.74%	28.05	5.14	17.10	38.00	.983	99	.235
Chemicals	4.15%	31.52	7.71	11.80	54.70	.990	554	.001
Industrial Conglomerates	0.93%	40.10	8.56	20.60	60.80	.986	124	.234
Insurance	2.19%	23.60	6.06	8.00	38.00	.989	292	.027
Machinery	4.07%	31.40	6.99	13.10	49.20	.994	543	.021
Media	1.79%	16.26	3.52	7.80	25.00	.989	239	.057
Oil & Gas Producers	1.16%	42.00	8.81	22.00	65.30	.987	155	.171
Paper & Forestry	0.50%	24.31	6.60	10.90	38.30	.972	67	.142
Pharmaceuticals	6.19%	30.68	7.03	8.50	47.30	.979	827	.000
Precious Metals	0.78%	34.89	12.08	7.90	62.40	.980	104	.111
Real Estate	6.88%	17.87	5.91	4.10	38.10	.986	919	.000
Refiners & Pipelines	1.21%	36.04	8.39	18.40	54.40	.979	161	.014
Retailing	3.17%	19.20	5.29	8.00	35.10	.991	424	.010
Semiconductors	2.76%	27.12	8.00	7.60	47.50	.988	369	.003
Software & Services	6.74%	22.00	5.00	6.50	35.10	.992	900	.000
Steel	1.15%	38.40	8.15	13.70	62.00	.994	153	.830
Technology Hardware	4.52%	19.72	6.06	4.50	36.60	.993	604	.009
Telecommunication Services	1.37%	25.11	6.12	10.50	46.30	.991	183	.349
Textiles & Apparel	1.43%	19.91	4.25	9.10	30.30	.991	191	.310
Traders & Distributors	1.24%	22.29	5.03	11.20	34.80	.994	165	.693
Transportation	2.52%	24.07	5.86	10.40	40.70	.979	336	.000
Transportation Infrastructure	1.11%	17.03	5.75	4.30	33.20	.992	148	.544
Utilities	4.49%	32.14	11.34	7.10	69.60	.983	600	.000
Total	13355	26.49	9.44	4.00	69.60			

Source: Authors´ calculations

From the perspective of dataset structure, the largest shares are represented by the banking industry (7.40%), real estate (6.88%), software & services (6.74%), and the pharmaceutical industry (6.19%). Conversely, the smallest proportions are observed in paper & forestry (0.50%), homebuilders (0.52%), and containers & packaging (0.55%). Despite the unequal representation of individual industries, the dataset can be considered sufficiently extensive for conducting a robust industry-level analysis of ESG risk, as it includes all publicly available data accessible from the Morningstar Sustainalytics database at the time of data collection.

The results presented in Table 1 reveal substantial variability across industries, reflecting industry-specific differences in exposure to environmental, social, and governance factors. The highest average ESG risk ratings are observed in industries characterised by considerable exposure to environmental and regulatory risks, such as diversified metals (Mean = 42.07; Std. Dev. = 10.95), oil & gas producers (Mean = 42.00; Std. Dev. = 8.81), the steel industry (Mean = 38.40; Std. Dev. = 8.15), construction & engineering (Mean = 38.47; Std. Dev. = 8.17), and industrial conglomerates (Mean = 40.10; Std. Dev. = 8.56). These findings reflect the high sensitivity of such industries to environmental regulation, carbon intensity, and increasing societal expectations regarding sustainability.

By contrast, the lowest average ESG risk ratings are concentrated in industries characterised by lower environmental burdens and relatively lower regulatory exposure. Particularly low values are identified in the media industry (Mean = 16.26; Std. Dev. = 3.52), transportation infrastructure (Mean = 17.03; Std. Dev. = 5.75), and real estate (Mean = 17.87; Std. Dev. = 5.91). Relatively low ESG risk ratings are also observed in technology hardware (Mean = 19.72), consumer durables (Mean = 20.06), and textiles & apparel (Mean = 19.91).

The overall mean ESG risk rating across all analysed firms equals 26.49 points, with a standard deviation of 9.44, indicating a moderate level of risk exposure within the applied ESG risk scale. Furthermore, the range between minimum and maximum ESG risk values within individual industries highlights substantial heterogeneity in corporate strategies and approaches to ESG risk management. For instance, the utilities industry exhibits the widest range of ESG risk values (from 7.10 to 69.60), suggesting considerable differences among companies operating within the same industry. This variability indicates that even in industries with high average exposure, some firms are capable of effectively managing and mitigating ESG-related risks.

The results of the Shapiro–Wilk test further indicate that the ESG risk variable does not exhibit a normal distribution across several analysed industries. At the significance level of $\alpha = 0.05$, the null hypothesis of normality was rejected in multiple industries, including banking, consumer services, pharmaceuticals, utilities, and technology hardware. These deviations from normality, together with unequal group sizes and the potential presence of outliers, represent important limitations for the application of parametric statistical methods. Consequently, the subsequent analysis employs non-parametric techniques, specifically the Kruskal–Wallis test and the Mann–Whitney U test, which do not require the assumption of normally distributed data and provide a more robust approach to analysing differences across industries.

3.2 Industry Differences in ESG Risk

The aim of this paper is to examine and quantify the relationship between ESG risk values and companies' industry affiliation, with a particular focus on identifying industries characterised by similar ESG risk profiles. To identify differences among multiple independent groups, the Kruskal–Wallis test was applied, followed by the Mann–Whitney U test.

Using the Kruskal–Wallis test, the mean rank of ESG risk values was determined for each industry (Mean Rank). Lower Mean Rank values indicate a tendency towards lower ESG risk values, whereas higher Mean Rank values suggest a higher level of ESG risk within a given industry. The Kruskal–Wallis test was employed to determine whether statistically significant differences exist in ESG risk distributions across industries. The tested hypotheses were as follows: H_0: all ESG risk values originate from the same distribution, H_1: at least one group of ESG risk values differs.

Based on the results of the Kruskal–Wallis test (Chi-Square = 5415.525, df = 40, Asymp. Sig. = 0.000), the null hypothesis is rejected, indicating statistically significant differences in ESG risk distributions across industries. Subsequently, industries were ranked according to the mean rank of ESG risk values from the lowest to the highest value (Table 2). The Mann–Whitney U test was then used to perform pairwise comparisons of ESG risk distributions between adjacent industries in the ranking. The Mann–Whitney U test was applied to identify statistically significant differences in ESG risk distributions between selected industry groups. The tested hypotheses were as follows: H_0: there is no statistically significant difference in ESG risk distributions between the compared industries, H_1: there is a statistically significant difference in ESG risk distributions between the compared industries. The hypotheses were tested at the significance level of $\alpha=0.05$. The results of the pairwise tests are presented in Table 2. Due to space limitations, it is not possible to interpret all results in detail; therefore, only selected findings are discussed.

The lowest mean rank of ESG risk was observed for firms operating in the media industry (Mean Rank = 2071.49), followed by the transportation infrastructure industry (Mean Rank = 2662.59). The result of the Mann–Whitney U test (U = 16483.00, Sig. = 0.261) did not confirm a statistically significant difference between these industries; therefore, the null hypothesis cannot be rejected. The ESG risk distributions of both industries are similar, and consequently, both industries were assigned to the same group characterised by the lowest level of ESG risk. The third lowest mean rank was identified in the real estate industry (Mean Rank = 2971.83). The comparison between transportation infrastructure and real estate using the Mann–Whitney U test (U = 63400.00, Sig. = 0.186) also did not reveal statistically significant differences in ESG risk distributions. Therefore, the real estate industry was likewise assigned to the first group of industries with the lowest ESG risk. Using the same procedure, a total of 40 pairwise Mann–Whitney U tests were subsequently conducted between adjacent industries. To reduce the risk of Type I error inflation associated with multiple comparisons, pairwise tests were conducted only between adjacent industries ordered according to their Kruskal–Wallis mean ranks. This procedure substantially reduced the number of comparisons relative to a full pairwise testing design and focused the analysis on identifying statistically justified boundaries between neighbouring industry groups.

The first statistically significant difference in ESG risk distribution was identified between the retailing and textiles & apparel industries (U = 36480.00, Sig. = 0.049). Based on the test results, the null hypothesis is rejected, indicating that ESG risk distributions differ significantly between these industries; therefore, they do not belong to the same group. Additional statistically significant differences were identified between the industries consumer durables and software & services (U = 69837.00, Sig. = 0.000), household products and utilities (U = 24006.50, Sig. = 0.002), machinery and precious metals (U = 23754.50, Sig. = 0.010), construction materials and refiners & pipelines (U = 7192.00, Sig. = 0.009), aerospace & defense and construction & engineering (U = 11577.00, Sig. = 0.009), steel and diversified metals (U = 12236.00, Sig. = 0.000), and diversified metals and industrial conglomerates

(U = 11166.50, Sig. = 0.035). Statistically significant differences in ESG risk distributions are highlighted in Table 2 using grey shading and bold font. Based on the results of the Mann–Whitney U test, industries were divided into nine groups according to the level of ESG risk (column 4 of Table 2 – “Group”). The individual groups reflect progressively increasing levels of ESG risk and represent distinct profiles of exposure to environmental, social, and governance factors.

Table 2: Kruskal-Wallis Mean Rank, Mann-Whitney U tests

Industries	N	K-W Mean	Group	Mann-Whitney U (Asymp. Sig. (2-tailed))	
Media	239	2071.49	1		
Transportation Infrastructure	148	2662.59	1	16483.00 (0.261)	
Real Estate	919	2971.83	1		63400.00 (0.186)
Containers & Packaging	74	3141.91	1	30568.00 (0.148)	
Retailing	424	3466.11	1		14811.00 (0.443)
Textiles & Apparel	191	3706.54	2	**36480.00 (0.049)**	
Technology Hardware	604	3793.35	2		56298.00 (0.617)
Consumer Durables	191	4010.09	2	56662.50 (0.712)	
Software & Services	900	4750.13	3		**69837.00 (0.000)**
Homebuilders	70	4864.36	3	31483.00 (0.994)	
Traders & Distributors	165	4890.98	3		5585.00 (0.690)
Auto Components	230	5286.20	3	17791.50 (0.290)	
Insurance	292	5560.86	3		31771.50 (0.290)
Transportation	336	5727.92	3	47869.50 (0.601)	
Food Retailers	169	5853.39	3		27095.00 (0.402)
Paper & Forestry	67	5976.65	3	5439.50 (0.639)	
Consumer Services	400	6158.76	3		12785.00 (0.547)
Telecommunication Services	183	6266.93	3	36035.50 (0.765)	
Banks	988	6289.11	3		88366.00 (0.628)
Healthcare	523	6377.67	3	254157.00 (0.602)	
Diversified Financial	725	6645.52	3		180533.50 (0.150)
Building Products	132	6893.05	3	46510.50 (0.609)	
Automobiles	80	6915.84	3		5159.00 (0.780)
Semiconductors	369	7067.67	3	14580.50 (0.865)	
Energy Services	94	7418.90	3		16388.00 (0.410)
Electrical Equipment	283	7681.81	3	12582.50 (0.432)	
Household Products	99	7758.81	3		13908.00 (0.915)
Utilities	600	8605.35	4	**24006.50 (0.002)**	
Pharmaceuticals	827	8814.00	4		241832.50 (0.415)
Chemicals	554	8958.28	4	224728.50 (0.549)	
Machinery	543	9046.79	4		147499.00 (0.579)
Precious Metals	104	9516.34	5	**23754.50 (0.010)**	
Food Products	516	9678.15	5		25462.00 (0.411)
Construction Materials	110	9750.52	5	28219.50 (0.926)	
Refiners & Pipelines	161	10378.14	6		**7192.00 (0.009)**
Aerospace & Defense	90	10535.47	6	7224.50 (0.970)	
Construction & Engineering	314	11140.14	7		**11577.00 (0.009)**
Steel	153	11141.47	7	23479.00 (0.692)	
Diversified Metals	209	11379.91	8		**12236.00 (0.000)**
Industrial Conglomerates	124	11409.42	9	**11166.50 (0.035)**	
Oil & Gas Producers	155	11831.76	9		8706.00 (0.177)

Source: Authors´ calculations

The results of the hierarchical cluster analysis (Figure 1) generally confirmed the industry classification obtained through the Kruskal–Wallis and Mann–Whitney tests. The dendrogram identified three major clusters representing low-, medium-, and high-risk industries. The high-risk cluster included Oil & Gas Producers, Industrial Conglomerates, Diversified Metals, Refiners & Pipelines, Aerospace & Defense, Steel, and Construction & Engineering, which is consistent with the results of the non-parametric tests. Conversely, Media, Transportation

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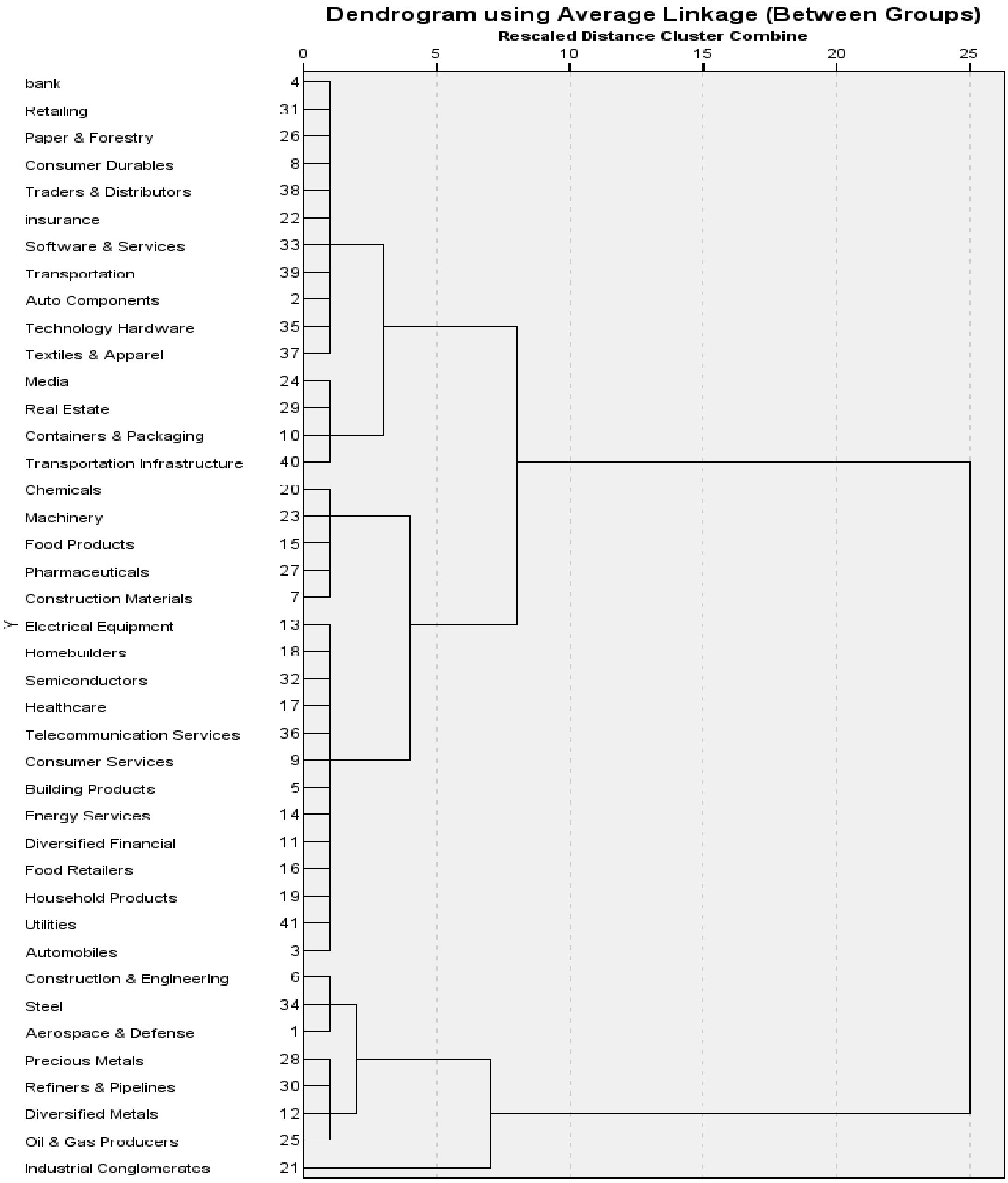
Infrastructure, Real Estate, and Containers & Packaging were classified among the industries with the lowest ESG risk levels. Differences between the two approaches stem from the fact that cluster analysis is based on aggregated average ESG risk values at the industry level, whereas the Kruskal–Wallis and Mann–Whitney tests utilise original firm-level observations and account for the entire distribution of ESG risk values within industries. The consistency between both approaches increases confidence in the robustness of the identified industry grouping structure. Consequently, the results of the cluster analysis should be interpreted as a complementary robustness check, whereas the final classification is primarily based on non-parametric statistical testing performed on firm-level observations.

Figure 1: Dendrogram



Source: Authors´ calculations

The first group consists of the industries media, transportation infrastructure, real estate, containers & packaging, and retailing, which exhibit the lowest levels of ESG risk. Despite their industry diversity, these industries share several common characteristics. Compared with

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environmentally intensive industries of the economy, they are exposed to lower direct environmental burdens and lower regulatory pressure, while social and governance-related aspects of ESG risk play a more significant role, particularly working conditions, consumer protection, reputational risks, and corporate governance. Environmental risks within these industries are primarily associated with the energy intensity of operations, material usage, waste generation, and indirect emissions across supply chains. In the media industry, environmental impacts are mainly related to the energy consumption of digital services and data infrastructure (Istrate et al. 2024, Sætra 2022), whereas in transportation infrastructure and real estate, the dominant factors include the energy intensity of infrastructure and the built environment. The containers & packaging and retailing industries face increasing pressure related to waste management, carbon footprint reduction, and sustainable supply chain management (Ferreira et al. 2019, Mayorova 2019). A common feature of the analysed industries is the growing emphasis on the active management of ESG factors through energy efficiency measures, recycling, circular economy principles, operational optimisation, and the reduction of environmental impacts (Corazza 2024). These measures likely contribute to their relatively low overall ESG risk profile.

The second group consists of the industries textiles & apparel, technology hardware, and consumer durables. Compared with the first group, these industries are characterised by higher material, manufacturing, and energy intensity, as well as more complex global supply chains, which contribute to their higher ESG risk profile. Nevertheless, compared with environmentally intensive industries, these industries maintain a relatively lower overall level of ESG risk. ESG risks within this group are primarily associated with high energy and water consumption, greenhouse gas emissions, waste generation, and the use of hazardous materials. Significant social risks are related to working conditions, human rights protection, and employee safety within global supply chains, particularly in developing countries (Abbate et al. 2023). In the textiles & apparel and consumer durables industries, increasing attention is devoted to circular economy practices and recycling (Hankammer et al. 2020, Musová et al. 2021), while in the technology hardware industry, major ESG concerns include rare mineral extraction, hazardous waste, and the carbon intensity of manufacturing processes (Sætra 2022).

The third and largest group consists of 19 industries, including insurance, banking, healthcare, automobiles, telecommunications, services, and energy services. Compared with the previous groups, these industries are characterised by higher regulatory and operational complexity, although without the dominant environmental burden typical of heavy industry. ESG risks within this group arise from a combination of environmental factors (carbon footprint, energy efficiency), social aspects (safety, access to services, consumer protection), and governance-related issues, particularly compliance and business ethics (Lopera-Mármol & Jiménez-Morales 2021). This group represents the “middle segment” of the economy, where ESG challenges are generally manageable through standard ESG governance mechanisms.

The fourth group comprises utilities, pharmaceuticals, chemicals, and machinery. These industries are characterised by greater environmental and regulatory sensitivity, with ESG risks closely linked to energy-intensive production, emissions, waste management, and operational safety. Increasing regulatory pressure and societal expectations regarding environmental responsibility also play an important role. In the utilities industry, dominant risks are associated with energy production, infrastructure development, and the environmental impacts of energy systems (Walker et al. 2021). The pharmaceutical industry faces not only environmental risks but also substantial ethical and regulatory challenges related to access to medicines and pharmaceutical waste management. Similarly, the chemicals and machinery industries are

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highly intensive in terms of energy, raw material, and water consumption, which increases both environmental and health-related risks (Hezam et al. 2024).

The fifth group includes food products, construction materials, and precious metals. A common characteristic of these industries is their high material and resource intensity, considerable environmental footprint, and elevated exposure to social and reputational risks. ESG risks are primarily associated with raw material extraction, energy consumption, emissions, waste generation, ecosystem degradation, and working conditions in agriculture and mining industries (Adeeyo et al. 2023). These industries are at the centre of public discussions regarding sustainability, responsible production, and the environmental transformation of the economy.

The sixth group consists of refiners & pipelines and aerospace & defense. The high ESG risk profile of these industries is primarily driven by their emission intensity, environmental impacts, and significant ethical and geopolitical concerns. The refiners & pipelines industry is associated with risks related to oil spills, toxic leaks, explosions, and other operational incidents that may result in severe environmental damage (Cekirge 2015, Cigolini & Rossi 2010). In the aerospace & defense industry, major concerns include greenhouse gas emissions and ethical issues related to the arms industry and exports to conflict regions (Abbate et al. 2023). Consequently, both industries face substantial regulatory and societal pressure.

The seventh group comprises construction & engineering and steel. The ESG risk profile of these industries is primarily shaped by high energy intensity, CO_2 emissions, and extensive use of natural resources. Significant social risks are also associated with occupational safety, labour conditions within supply chains, and the impacts of large-scale projects on local communities. Governance-related challenges include regulatory compliance, ethical sourcing of materials, and transparent stakeholder engagement (Erhart & Erhart 2023).

The eighth group consists solely of the diversified metals industry. ESG risks in this industry are associated with the entire production cycle, from raw material extraction to processing and refining. The industry is characterised by high water and energy consumption, CO_2 emissions, ecosystem degradation, and negative impacts on human health. Significant social risks include working conditions, occupational health and safety, community relations, and indigenous rights (Lèbre et al. 2019, 2020; Abid et al. 2021). This industry represents one of the most ESG-exposed industries, where risk management is exceptionally complex and capital intensive.

The final group consists of industrial conglomerates and oil & gas producers. The ESG risk profile of this group results from a combination of environmental intensity, operational complexity, and geopolitical factors. The oil and gas industry faces increasing pressure due to climate change and decarbonisation policies, while industrial conglomerates are characterised by highly diversified operations and complex ESG governance structures (Cekirge 2015, Cigolini & Rossi 2010). Significant social risks include occupational safety, labour rights protection, and compliance with health standards (Hezam et al. 2024). Governance challenges are primarily related to integrating ESG principles into the management of operational, financial, and reputational risks (Abbate et al. 2023).

The results confirm that industries can be clearly differentiated according to the level of ESG risk. Groups 1 and 2 represent low-risk industries characterised by lower environmental intensity and predominantly social and reputational risks. Groups 3 and 4 represent a medium-risk segment of the economy, where ESG risks are relatively manageable through standard ESG governance mechanisms. In contrast, Groups 5 to 9 include industries with substantial

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environmental, social, and regulatory exposure, where ESG risks are primarily driven by material intensity, emission intensity, natural resource consumption, and the complexity of global operational and supply chain structures. Overall, the identified grouping structure suggests that differences in ESG risk are primarily associated with variations in environmental intensity, resource dependence, regulatory exposure, and supply-chain complexity rather than with individual firm characteristics alone.

Conclusion

The aim of this paper was to examine the relationship between ESG risk values and industry affiliation and to identify groups of industries characterised by similar ESG risk profiles. Based on the analysis of data from 13,355 companies operating across 41 industries, statistically significant differences in ESG risk distributions among industries were identified using the Kruskal–Wallis test followed by Mann–Whitney U tests. The results enabled the classification of the analysed industries into nine groups according to the level of ESG risk.

The findings confirm that ESG risk is strongly determined by the nature of economic activity, the environmental intensity of production, the regulatory environment, and the complexity of supply chains. The lowest ESG risk levels were identified in industries with lower material and environmental intensity, whereas the highest risk levels were observed in industries associated with raw material extraction, energy production, metallurgy, and emission-intensive industrial activities. The results further indicate that increasing regulatory pressure, societal expectations, and transparency requirements significantly influence the ESG risk profile of firms across industries.

The findings have practical implications for investors, corporate managers, regulators, and ESG strategy developers. The identification of industry-specific differences in ESG risk may contribute to more effective ESG risk management, improved investment risk assessment, and the more targeted design of regulatory and sustainability policies. The results also highlight the need for a differentiated approach to ESG assessment across industries, as corporate risk profiles vary substantially depending on the nature of their economic activities.

From a theoretical perspective, the study contributes to the ESG literature by demonstrating that industry affiliation represents an important determinant of ESG risk exposure. While previous research has primarily focused on ESG rating divergence, ESG materiality, or the relationship between ESG performance and financial outcomes, this study provides a systematic empirical classification of industries according to ESG risk levels, supported by both non-parametric statistical testing and hierarchical cluster analysis. The identified grouping structure contributes to a better understanding of industry-level ESG risk heterogeneity and supports the growing discussion on the materiality of ESG factors across industries.

The study is subject to several limitations. The analysis relied exclusively on data obtained from the Morningstar Sustainalytics database available at the time of data collection, while the exact representativeness of the sample could not be verified due to the absence of comprehensive information on the total number of firms operating within individual industries globally. Another limitation arises from the fact that ESG ratings represent dynamic indicators influenced by temporal developments, regulatory frameworks, geographical conditions, and the methodologies applied by individual ESG rating providers. In addition, the analysis was conducted at the global industry level and did not explicitly control for country-specific regulatory, institutional, or cultural factors that may influence ESG risk assessments. Therefore, part of the observed variation may also reflect geographical differences in ESG-related practices and reporting standards. Furthermore, the study relies on multiple pairwise Mann–Whitney comparisons and does not apply formal correction procedures for family-wise error rates. Although the number of comparisons was substantially reduced by testing only adjacent industries, marginally significant results should be interpreted with caution.

Future research could focus on longitudinal analyses of ESG risk development over time, comparisons among different ESG rating providers, or a more detailed examination of regional and regulatory factors affecting corporate ESG risk profiles. Another promising direction for future research is the analysis of the relationship between ESG risk and corporate financial performance across industries.

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