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Impact of Environmental, Social, and Governance (ESG) Scores on International Credit Ratings: A Sectoral and Geographical Analysis

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Abstract

This study examines the relationship between environmental, social, and governance (ESG) scores and credit ratings across regions and industrial sectors using a dataset of 188 companies from Europe and the US (2013–2023). Employing ordered probit regression and Granger causality tests, the analysis reveals that, in Europe, higher ESG scores—particularly in human rights and governance—are associated with lower credit ratings, while in the US, resource use and shareholder engagement positively influence credit ratings. Sector-specific effects highlight the importance of environmental performance in healthcare and controversy management in consumer sectors. These findings emphasize the need for region- and sector-specific approaches when integrating ESG factors into credit risk assessments.

Keywords: ESG scores; credit ratings; accounting; geographic regions; industrial sectors; ordered probit model

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1. Introduction

Credit ratings play a central role in global financial markets, serving as a key measure of an entity's creditworthiness and influencing investment decisions, regulatory compliance, and the cost of capital. Traditionally, credit rating agencies have relied on a combination of financial ratios and qualitative assessments, but recent years have seen a growing emphasis on non-financial factors, particularly those related to environmental, social, and governance (ESG) performance. This shift is driven both by regulatory initiatives, such as the European Union's Sustainable Finance Action Plan, and by increasing stakeholder demand for transparency and sustainability in corporate behavior.

While a substantial body of literature suggests that strong ESG performance is generally associated with higher credit ratings and reduced credit risk, the evidence remains inconclusive and, in some cases, contradictory. Much of the existing research treats ESG as

a single, aggregated measure or focuses on specific regions or industries, often neglecting the possibility that individual ESG pillars—environmental, social, or governance—may have distinct and sometimes opposing effects on credit ratings. Furthermore, the dynamic relationship between changes in ESG scores and changes in credit ratings over time has not been thoroughly explored, with only limited studies addressing this aspect and typically within narrow samples or specific sectors.

Rating agencies, via a through-the-cycle approach, use quantitative and qualitative information from financial statements, any published information about an entity, and judgments [1]. They face governmental regulation [2]. The official role of credit ratings is voluntary internationally [2]. The unique informational set of ratings is as important for corporations as the publication of accounting data. As geographical economic entities, the US and the EU have heavily emphasized the role of credit ratings in economies and financial markets internationally. The role of credit ratings in both the EU and the US is depicted by policymakers and regulators [3]. The 2000 Fair Disclosure regulation in the US gave credit agencies access to more confidential information and made credit ratings more important for policymakers, regulators, and investors [4]. Credit ratings inform investors about default and credit risks, while debt issuers refer to the magnitude of investment risk and transparency [5,6]. Any change (upgrade or downgrade) in credit rating results in changes in the entity's cost of capital.

Apart from the role of credit ratings in default risk and the market reactions to changes in credit ratings, another important stream in the literature is the determinants of credit ratings. These determinants are financial and non-financial, as credit ratings incorporate financial and non-financial information [7,8]. The former concerns information from financial statements, and the latter concerns corporate social responsibility (CSR) [9,10]. The former are consistent mostly from firm-specific factors (as peroxided by financial ratios) and macroeconomic factors (like GDP growth) [11,12]; whereas the latter refers to corporate CSR. The credit risk and ratios literature started from the prediction of bankruptcy using financial ratios [13] and proceeded to the prediction of credit ratings [14]. There was a statistically significant effect of ratios on credit ratings; this effect varies with the ratios employed [15]. Such a relation exists because ratings and ratios contain distinct information sets.

The relation of credit ratings with CSR has recently been evident in the literature. Both are important to policymakers, regulators, and investors. The EU's 2018 Sustainable Finance Action Plan [16] emphasized the incorporation of environment, social, and governance (ESG) activities into credit ratings. CSR activities decrease the risk of information asymmetry [17]. Governance mechanisms that affect the ESG features of an entity can improve credit ratings [18]. Corporate boards affect ratings, as they motivate and monitor management [19]. Corporate governance may be expressed as rules, procedures, management philosophy, and organizational structure, among others [10]. It enables the reduction of bankruptcy and credit event risks via an adequate internal environment and control system. Its impact on credit ratings is statistically significant and positive [20].

This study aims to address these gaps by providing a comprehensive analysis of the relationship between ESG scores and international credit ratings, with a particular focus on how these relationships vary across sectors and between European and US companies. Using a unique dataset of 188 companies with consistent ESG and credit rating data from 2013 to 2023, the research investigates not only the overall impact of ESG performance on credit ratings but also the specific influence of individual ESG pillars and sub-components. The methodology employs an ordered probit model and Granger causality tests to capture both cross-sectional and temporal dynamics, while controlling for traditional financial determinants such as leverage, size, profitability, sales growth, and dividend yield.

Based on the identified gaps and the objectives of this study, we examine the following hypotheses.

Hypothesis 1. *The relationship between environmental, social, and governance (ESG) scores and credit ratings is not uniform but varies significantly between European and US companies.*

Hypothesis 2. *The impact of ESG scores on credit ratings is sector-dependent, meaning that the influence of individual ESG pillars (environmental, social, governance) and their sub-components on credit ratings differs across industry sectors.*

Hypothesis 3. *Changes in ESG scores can serve as predictors for changes in credit ratings over time, but this predictive relationship is both region- and sector-specific.*

These hypotheses are empirically examined in the following sections.

We contribute to the literature in the following ways. First, we examine the relation between ESG scores and credit ratings internationally. Second, we reveal the differences between Europe and the US.

The remainder of the paper proceeds as follows: Section 2 describes the literature, and Section 3 explains the data. Section 4 outlines the methodology, Section 5 presents the empirical findings, and Section 6 offers the concluding remarks.

2. Literature Review

The recent literature has used different measures of credit risk and financial risk. Research is consistent that higher ESG scores, in general, are associated with higher credit ratings and lower credit risk (see Table 1 for a comprehensive review). This relationship arises from the perspective that superior ESG practices enhance risk management, operations effectiveness, and stakeholder confidence for a firm, collectively reducing credit risk. This result is consistent across international settings and sectors, even after controlling for the size of the company. Studies with samples from European countries [1–5], the United States [6–8], China [9], Japan [10], Korea [11], or at the global level [12–15] have demonstrated that ESG performance is associated with a reduced financial risk—higher credit ratings, lower cost of debt, and lower probability of default. This is an expected result based on stakeholder theory [16].

Table 1. A summary of ESG predictors that positively influence credit ratings and credit risk.

Countries of Study/Industry	Dependent Variables	Predictors (Sign of Significant Influence)	Theoretical Framework
US/All sectors	Probability of default	ESG overall score (−) E, S separate scores (−)	Stakeholder theory
India/All sectors	Credit rating (S&P)	ESG score (+) for medium firms but not large firms	Stakeholder theory
Europe/All sectors	Cost of debt	ESG score (−)	-
Europe/Banks	Credit ratings (Moody's, S&P, and Fitch)	ESG overall score (Fitch) (+) E score (all) (+) G score (Fitch) (+)	Stakeholder theory
Europe/All sectors	Credit rating (Moody's and Fitch)	ESG overall score (Fitch) (−) E score (Moody's and Fitch) (−) G score (Fitch) (−) (significant for energy, basic materials, industrials, technology, utilities)	Perspective theory

Table 1. *Cont.*

Countries of Study/Industry	Dependent Variables	Predictors (Sign of Significant Influence)	Theoretical Framework
China/All sectors	Credit risk (credit default swap spread)	ESG overall score (−) E, S, G separate scores (−) Emissions (−) Water consumption (−) Employee turnover (+) Donations (−) Sustainability disclosure (−) Assurance (−) Negative news (+)	-
Taiwan/All sectors	Credit risk (high risk = high score)	CSR Strategy score (−)	Signaling theory
Global sample/All industries	Financial risk (Cost of capital)	E, S, G separate scores (−)	Legitimacy theory
Europe/Non-financial	Cost of debt (interest expense to average debt) Credit ratings (Fitch)	ESG overall score (+)	Stakeholder theory/Legitimacy theory
Germany/All sectors	Credit ratings (S&P)	ESG linguistic features (+)	-
Japan/All sectors	Credit ratings (S&P)	ESG overall score (+) G separate score (+)	-
Europe and the US/Non-financials	Market reaction to credit rating change	ESG factors → assessment of downside risks on credit quality	-
US/All sectors	Credit ratings (S&P)	ESG overall score (+) E, S, G separate scores (+)	Portfolio theory
US/All sectors	Market reaction to credit rating change	High ESG scores → positive market reaction when credit ratings are upgraded	Stakeholder theory
Global firms/High-tech	Leverage (total liabilities/total assets)	ESG overall scores (−) E, S, G separate scores (−)	-
Not specified	Credit ratings (Starmine)	Cumulative issuance of green bonds (+)	-
Europe/All sectors	Cost of debt (interest paid/interest-bearing debt)	ESG overall score (+) in weak legal environments	Stakeholder theory
China and Japan/Sectors not specified	Credit ratings (local credit rating agencies)	ESG overall (+) Japan E (+) Japan E (−) China S (−) Japan G (+) China and Japan	Stakeholder theory
Brazil, Canada, UK/Banks	Credit ratings (multiple providers)	Governance pillar score (−) Resource use (+) (Granger causality, excluding COVID-19 effects)	Agency theory
Korea/Sectors not specified	Cost of debt	ESG overall score (−) E, S, G separate scores (−) (contemporaneous and 2-year lag)	Stakeholder theory, upper echelons theory, and managerial cognition theory
Countries not specified/Non-financial companies	Credit ratings (S&P)	Managerial ability in interaction with ESG scores (+)	-
Countries not specified/Non-financial companies	Credit ratings (S&P)	ESG overall score (+) E, S separate scores (+) G separate scores (+) only in manufacturing, real estate, IT	

However, the studies included in Table 1 do not clarify how changes in ESG ratings influence the changes in credit ratings, if they do. This is a corollary of signaling theory [17]—we are not talking about fixed levels of ESG performance but a certain dynamic over time. Credit ratings change as well but with a lower frequency. If there is a true relationship between ESG ratings and credit ratings, it should be evident in the dynamic interaction between these two variables. Only one study [18], as reviewed below, has attempted to clarify this relationship for a limited sample of banks in three countries. Therefore, this is a significant research gap that can be addressed in the present research.

The literature review in Table 1 also shows that results are not stable across all dimensions of the ESG spectrum. In several situations, only one of the pillars (either the environmental, social, or governance pillar) produces the desired effect [2,6,10,15,19,20]. Therefore, considering the overall ESG score as a proxy for sustainability performance

alone does not provide the correct picture. It is necessary to disaggregate the ESG dimensions to clarify the influence of specific ESG aspects on the evolution of credit ratings. This reasoning has been applied in relation to financial performance [21], and previous research has shown that some ESG dimensions have a positive impact on credit ratings. In contrast, others have a negative or statistically non-significant effect [10,22]. The correct methodological approach is to separate these effects in statistical analysis.

The findings in Table 1 illustrate the multiple dimensions of ESG scores' impact on credit ratings across various regions and sectors, as well as the growing relevance of sustainable practices in global financial assessments. However, the literature review summarized above does not answer the research question proposed by this paper: *Does the evolution of ESG scores influence the evolution of credit ratings, with a breakdown by industry and sustainability pillars?* The Granger causality test, as described in Section 4, is a solution to answer the research question.

3. Data

The entire dataset was retrieved by Refinitiv, Reuters, consistent with other datasets [23–29]. A higher number in any ESG score or sub-score means better performance in any ESG factor [30]. There are 16 ESG scores overall. These scores include: 2 overall (combined and total) ESG scores; 4 scores for the respective pillars (environment, social, and governance) with controversies score as well; 3 sub-scores for the environmental pillar (resource use, emissions, and innovation); 4 sub-scores for the social pillar (workforce, human rights, community, and product responsibility); and three sub-scores for the governance pillar (management, shareholders, and CSR strategy). Credit ratings are the ones that the Refinitiv database has [31]. The start and end dates are 21 January 2013 and 19 January 2023. The final number of companies used in the sample, and for completeness purposes, was 198; 98 were from the US, and 100 were from Europe. Half of them are companies with ESG scores (in the entire sample period), and the other half are companies without consistent ESG scores (for the whole sample period). Most European countries have most of their companies complying with ESG (in the sample, for the entire period), whereas the opposite happens for US countries. This is followed by the number of companies with and without ESG for Europe and the US in the sample. The numbers of companies with and without ESG are, in most countries, equal. Data was also split into 20 sectors which had the highest liquidity across all countries in the sample. Each sector has equal numbers of companies with and without ESG. Table 1 describes the data. We can see the importance of each sector in the sample via the number of companies included. The most important sectors are "Pharmaceuticals" and "Real Estate Rental, Development & Operations". The least important seem to be "Construction & Engineering", "Gold", and "Online Services".

4. Methodology

The study employs the ordered probit model as it is specifically suited for modeling credit ratings, which are ordinal variables rather than continuous ones. Unlike linear regression models, which require arbitrary numerical assignments to rating categories and assume equal distances between them, the ordered probit model respects the natural ordering of credit ratings and avoids these restrictive assumptions. This approach produces more accurate and interpretable estimates when analyzing the determinants of credit ratings, as supported by both the academic literature and practical applications in the credit rating industry. While models such as OLS or random effects can be easier to compute, they are prone to bias and misclassification when applied to ordinal outcomes. In contrast, the ordered probit model offers a better fit and more balanced prediction errors across the credit rating spectrum. Ref. [32] tried different models for assessing the relation between CSR and credit risk. They used S&P's corporate credit ratings and converted the letter

combination of these ratings into an ordinal scale, where higher rating values indicate lower default risk. Following this paper, we also converted the letter combination of Fitch's credit ratings into an ordinal scale, where higher values represent lower default risk.

However, we employed the logarithmic returns series and subsequently annualized the estimation of these series. Descriptive statistics concern the average values across the companies of each sector, regarding credit ratings (annual ln returns), ESG (in levels), and control variables (in levels). Results reported for correlations and Granger causalities are average values across the companies of each sector. Average values are reported without dispersion metrics, as dispersion values (within each sector) were not significantly high compared to average values. Sectoral dispersion was not relevant to the scope of the paper.

Ref. [32] employed a fixed effects panel regression to address potential endogeneity effects in the credit–ESG relationship. The OLS estimation method delivered identical results. We also tried a pooled ordered probit estimation with firm-fixed effects on the levels of the ordinal scale of Fitch's credit ratings (not in returns). These results were not reported because they did not differ substantially from the main estimations and did not add to the clarity of the findings.

Following this paper, we use an ordered probit model to examine the impact of ESG ratings on credit ratings, where the dependent variable is credit ratings and the independent variable is the various ESG scores. The model selection concerns the ordinal scale measurement of credit ratings. Both OLS and probit models are ordered methods, incorporating the fact that ratings are ranked. A problem of the OLS is that it considers ratings as an interval scale in which there is an equal scaling among all rating classes. However, the probit model addresses this scaling problem.

Nevertheless, both models assume that explanatory variables may influence the dependent variable evenly across all values of credit ratings. Moreover, the probit model cannot be used for forecasting ratings, as it assumes a point-in-time perspective instead of the through-the-cycle approach [31].

$$Cr_{i,t} = a + b * ESG_{i.t} + c * X_{i,t} + e_{i,t}$$

where

$Cr_{i,t}$ is the credit rating,

$ESG_{i,t}$ is any of the 16 ESG scores, and

$X_{i,t}$ are the control variables; for each company (or industry) i.

Control variables are: Leverage (total liabilities to total assets ratio), Size (natural logarithm of total assets), Profitability (operating income divided by total assets), Sales Growth (growth rate of sales), and Dividend Yield (dividend per share divided by share price).

The software used was EViews 10 (version 10.0; 2017). In our case, there are multiple multicollinearity issues because *ESG* and *X* variables have different information sets concerning non-financial and financial information, respectively. There should be no endogeneity as the frequency of analysis (annual) does not impose such issues.

4.1. Propensity-Score Matching (PSM)

To address selection on observables, propensity-score matching is employed to compare firms in the top ESG quartile ("treated") with those in the bottom quartile ("controls") within each year.

Propensity scores are estimated by a logistic model including Leverage, Size, Profitability, Sales Growth, and Dividend Yield, together with year- and sector-dummy variables.

Matching uses nearest neighbor (1:1) with replacement under the common-support restriction. Covariate balance is evaluated by standardized mean differences (SMDs) before

and after matching; inference on the average treatment effect on the treated (ATT) is based on 500 bootstrap replications.

Alternative kernel and radius matching confirm the robustness of the findings.

4.2. Instrumental-Variables (IV) Approach

To mitigate potential endogeneity between ESG and credit rating outcomes, an instrumental-variables strategy is adopted.

Two instruments are used:

(i) a sector-year "Bartik-type" ESG shock, computed as the global (outside-region) ESG change in each sector-year excluding the firm's own region; and

(ii) a regulatory-salience indicator, capturing the introduction of the EU Directive 2014/95/EU on non-financial disclosure (versus the absence of an equivalent US shock).

First-stage F-statistics confirm instrument relevance, and Hansen J tests do not reject over-identifying restrictions.

Second-stage regressions are estimated using IV-ordered-probit and two-stage least-squares specifications, which provide local average treatment effects.

4.3. Exogenous Policy Shock (Difference-in-Differences)

A difference-in-differences (DiD) framework further isolates causal effects by exploiting the EU Directive 2014/95/EU as an exogenous policy shock.

European firms constitute the treated group; US firms serve as the control group.

Firm- and year-fixed effects models examine the post-2017 change in the ESG–credit rating relationship, while event-study leads and lags verify parallel trends.

Standard errors are clustered at the firm level.

5. Empirical Findings

5.1. Descriptive Analysis

European companies exhibit slightly higher average credit ratings and ESG Combined Scores compared to their US counterparts, indicating generally better creditworthiness and ESG performance in Europe. When examining sectoral differences, Basic Materials stands out for its high average ESG scores, while Financial Services records the lowest. The Health Care sector demonstrates strong results in both the social and governance pillars. However, credit ratings vary by sector, with Energy showing the highest average and Financial Services the lowest (Table 2).

Table 2. Data description.

	Total
Companies	198
	Regions
Europe	100
US	98
	Countries
Sweden	21
Switzerland	14
UK	65
US	98

Table 2. *Cont.*

	Total
	Sectors
Basic Materials	17
Communication Services	12
Consumer Cyclical	22
Consumer Defensive	27
Energy	6
Financial Services	17
Health Care	23
Industrials	37
Real Estate	4
Technology	13
Utilities	20

Notes. All companies had a continuous publicly available stream of information about ESGs, credit ratings, and control variables within the sample period.

Descriptive statistics for the main variables are reported in Table 3. They indicate notable regional differences: European firms show higher ESG levels and lower volatility, whereas US firms exhibit greater dispersion and higher Leverage and Sales Growth. These patterns justify analyzing Europe and the United States separately in subsequent sections.

Variability within sectors is also notable. The Financial Services sector has the widest range in ESG performance, while Real Estate shows the most consistency. Dispersion in credit ratings is greatest in the Energy sector. Median values for ESG and credit ratings often mirror the averages, but Real Estate's high median ESG Combined Score suggests that most firms in this sector perform well on ESG metrics. Some sectors, like Health Care, display extremely high median social pillar scores, reflecting a strong sectoral emphasis on social responsibility.

Data distribution characteristics further illustrate sectoral nuances. For example, the Energy sector's emissions scores are positively skewed, indicating that most companies have lower emissions, while the Basic Materials sector's governance pillar is negatively skewed, showing a concentration of high governance scores. Utilities' credit ratings are sharply peaked around the mean, whereas Technology's environmental pillar score is more evenly spread.

Overall, these descriptive statistics reveal considerable regional and sectoral diversity in both ESG scores and credit ratings. European firms tend to have higher and less variable scores, while sectoral analysis highlights that areas like Health Care and Basic Materials outperform others, such as Financial Services. These patterns underscore the importance of considering both regional and industry context when assessing the relationship between ESG performance and credit ratings.

Taken together, these findings highlight that Europe generally outperforms and is more consistent in both creditworthiness and ESG performance (see Table 3). Uniform regulatory standards or cultural factors may contribute to this advantage and stability. At the sectoral level, Basic Materials excels in ESG—especially in governance—though its creditworthiness is only moderate. Financial Services consistently lags in ESG metrics and experiences the most significant internal disparity, while Health Care is especially strong in the social pillar and governance. The Energy sector is exceptional for environmental scores. Still, it features the widest variability and some negative outlier behavior, while Real Estate's high medians and low variance suggest uniformly strong ESG performance.

In Table 4, European and Real Estate firms are typically higher-performing and less variable in ESG/credit standings. Financial Services and Utilities are laggards, with the latter exceptionally consistent but poorly rated. Sectoral and regional context is crucial: variability, skewness, and kurtosis evidence the presence of distinct outlier behaviors and systemic sectoral strengths/weaknesses. Regional and industry contexts critically shape both ESG and credit rating outcomes. European and Real Estate firms consistently deliver above-average, stable results, while Financial Services and Utilities often lag. Not only do the means and medians tell this story, but the patterns of variability, skewness, kurtosis, and normality tests all expose the underlying structural differences within and between regions and sectors, allowing investors and policymakers to target the most pressing issues for intervention or investment.

Table 3. Descriptive statistics (Europe vs. US).

	Average		Std. Deviation		Median		Skewness		Kurtosis		Jarque–Bera (Stat.)	
	Europe	**US**	**Europe**	**US**	**Europe**	**US**	**Europe**	**US**	**Europe**	**US**	**Europe**	**US**
Credit ratings	0.0011	−0.0074	0.1228	0.1682	2.71×10^{-16}	2.98×10^{-16}	−0.5738	−1.36	4.79	12.51	182.27 **	3202 **
ESG scores												
ESG Combined Score	66.61	61.48	16.76	16.21	66.67	58.33	−0.34	−0.11	2.46	2.23	30.63 **	21.24 **
ESG Score	71.58	68.57	17.19	15.68	75.00	75.00	−0.64	−0.65	2.86	2.87	66.65 **	56.33 **
Environmental Pillar Score	69.95	64.45	23.47	23.64	75.00	75.00	−0.71	−0.89	2.53	2.93	91.40 **	104.73 **
Resource Use	77.26	71.48	26.45	28.27	83.33	83.33	−1.11	−0.91	3.22	2.75	200.97 **	110.67 **
Emissions	75.74	70.57	23.93	26.00	83.33	75.00	−1.00	−0.86	3.14	2.91	162.28 **	97.53 **
Innovation	50.90	42.00	33.88	30.99	50.00	33.33	−0.01	0.37	1.44	1.71	98.36 **	72.05 **
Social Pillar Score	74.52	71.20	19.30	18.85	75.00	75.00	−0.80	−0.56	3.03	2.48	103.94 **	49.80 **
Workforce	83.84	75.24	16.72	21.35	91.67	83.33	−1.09	−0.73	3.80	2.76	219.89 **	71.79 **
Human Rights	69.44	56.51	30.96	32.56	83.33	66.67	−0.81	−0.32	2.34	1.70	124.87 **	68.96 **
Community	73.42	87.00	26.55	14.74	83.33	91.67	−0.80	−1.21	2.40	3.98	118.60 **	222.29 **
Product Responsibility	66.90	66.16	29.86	26.20	75.00	75.00	−0.58	−0.41	2.09	1.98	87.12 **	56.45 **
Governance Pillar Score	69.47	67.90	20.15	19.02	75.00	66.67	−0.59	−0.50	2.70	2.45	59.44 **	42.34 **
Management	70.79	69.53	24.83	24.96	75.00	75.00	−0.63	−0.52	2.40	2.27	77.80 **	52.10 **
Shareholders	62.21	62.47	28.04	24.35	66.67	66.67	−0.30	−0.30	1.85	2.16	67.91 **	34.82 **
CSR Strategy	73.96	67.69	23.96	31.95	83.33	75.00	−0.99	−0.73	3.22	2.16	161.20 **	93.05 **
Controversies	83.08	75.39	28.54	32.59	100.00	100.00	−1.52	−0.98	3.83	2.37	402.35 **	138.93 **
Control variables												
Leverage	4.79	5.71	18.06	35.86	2.38	2.80	10.96	26.56	130.91	728.80	681,379 **	17,322,746 **
Size	0.81	0.88	0.54	0.78	0.71	0.64	1.88	3.06	9.90	14.46	2499 **	5515 **
Profitability	1.29	1.16	2.65	0.70	0.95	1.05	18.41	1.85	414.63	8.11	6,910,033 **	1303 **
Sales Growth	9.01	15.84	12.82	25.25	5.50	7.30	7.29	3.73	84.40	20.02	276,704 **	11,294 **
Dividend Yield	0.48	0.46	0.24	0.22	0.47	0.44	0.10	0.06	2.26	2.11	24.03 **	26.67 **

Notes. Values concern all companies for each sector. ** indicate statistical significance at a 5% level. Full details are also available in Tables A1–A6 (Appendix A).

Table 4. Key Descriptive Patterns.

Dimension	Best-Performing	Most Variable	Most Consistent	Worst-Performing
Credit Ratings	Europe, Energy	Energy	Communication Svcs	Financial Services
ESG Combined Score	Real Estate, Europe	Financial Services	Real Estate	Utilities, Fin. Svcs
Environmental Pillar	Energy, Basic Mat.	Technology	Real Estate	Utilities
Social Pillar	Health Care, Cons. Def.	Financial Services	Real Estate	Utilities
Governance Pillar	Basic Mat., Real Estate	Financial Services	Real Estate	Financial Services

5.2. Correlation Analysis

This section presents the pairwise correlations between credit ratings and various ESG scores and control variables for European and US companies (Table 5). In Europe, the correlations between credit ratings and ESG scores are generally weak and mostly negative. The ESG Combined Score displays a very weak negative correlation of −0.0116, while the ESG Score has a negligible positive correlation of 0.0010. The Resource Use Score shows a slight positive correlation of 0.0144 among the environmental scores, while Emissions is weakly negative at −0.0106. Social Pillar Scores, including Human Rights (−0.0472) and Community (−0.0228), exhibit weak negative correlations with credit ratings. The Governance Pillar Score and Management show almost no correlation with values of −0.00039 and 0.00049, respectively. Control variables such as Leverage (−0.0070), Size (−0.000625), and Profitability (−0.0319) also show weak correlations, suggesting a limited impact on credit ratings in Europe.

Table 5. Pairwise correlations between credit ratings and ESGs as well as control variables (Europe vs. US).

	Europe	**US (US)**
ESG Combined Score	−0.0116	−0.0419
ESG Score	0.0010	−0.0301
Environmental Pillar Score	0.0041	−0.0050
Resource Use	0.0144	−0.0050
Emissions	−0.0106	−0.0096
Innovation	−0.0026	−0.0152
Social Pillar Score	−0.0263	−0.0247
Workforce	0.0050	−0.0150
Human Rights	−0.0472	−0.0351
Community	−0.0228	−0.0288
Product Responsibility	0.0065	−0.0076
Governance Pillar Score	-3.90×10^{-4}	−0.0477
Management	4.90×10^{-4}	−0.0642 *
Shareholders	0.0128	0.0215
CSR Strategy	−0.0268	−0.0054
Controversies	−0.0025	−0.0262
Leverage	−0.0070	0.0205
Size	-6.25×10^{-4}	−0.0237
Profitability	−0.0319	−0.0135
Sales Growth	−0.0188	0.0057
Dividend Yield	−0.0174	−0.0230

Notes. * Indicate statistical significance at a 10% level.

In the US, correlations are similarly weak but slightly more negative overall. The ESG Combined Score (see Table 5) negatively correlates −0.0419 with credit ratings, while the ESG Score shows −0.0301. Environmental Pillar Scores like Resource Use and Emissions have weak negative correlations of −0.0050 and −0.0096, respectively. Social scores such as the Social Pillar Score and Human Rights display weak negative correlations of −0.0247 and −0.0351. The Governance Pillar Score and Management show weak negative correlations of −0.0477 and −0.0642, respectively. Among the control variables, Leverage (0.0205) and Sales Growth (0.0057) show weak positive correlations, whereas Size (−0.0237) and Profitability (−0.0135) show weak negative correlations (Table 5).

As displayed in Table 6, the pairwise correlations between credit ratings and ESG scores across different sectors are presented. In the Basic Materials sector, the ESG Combined Score and ESG Score exhibit weak negative correlations of −0.0837 and −0.0564,

respectively. Additionally, the Environmental Pillar Score (0.0763) and Resource Use (0.0232) demonstrate a positive correlation, while Human Rights (−0.0496) and Governance Pillar Score (−0.1150) show weak negative correlations. The Communication Services sector reveals weak correlations with ESG scores, with the ESG Combined Score at 0.000098 and the ESG Score at 0.0254. Furthermore, Workforce (−0.1029) and Social Pillar Score (−0.0803) exhibit weak negative correlations, while Innovation (0.0582) displays a positive correlation.

In the Consumer Cyclical sector, the ESG Combined Score stands at −0.0188, and the ESG Score is 0.0341, demonstrating generally weak correlations. Social scores, such as Workforce (−0.1001), show a weak negative correlation. The ESG Combined Score (0.0443) and ESG Score (−0.0119) exhibit weak correlations in the Consumer Defensive sector. The Social Pillar Score (0.0224) and Workforce (−0.0489) reveal weak correlations, indicating minimal impact on credit ratings. In the Energy sector, the ESG Combined Score (0.0188) and ESG Score (0.0403) present weak positive correlations, while Human Rights (−0.0462) and Shareholders (−0.1623) show negative correlations. Also, the Financial Services sector exhibits weak negative correlations for the ESG Combined Score (−0.0338) and ESG Score (−0.0088), with governance scores such as Shareholders (−0.0467) and Management (0.0053) displaying varying correlations.

On the other hand, the healthcare industry shows a negative correlation in the ESG Combined Score (−0.1173) and a positive correlation in emissions (0.0921). Human Rights (−0.0369) and Management (−0.0365) exhibit weak negative correlations. The industrial sector displays weak negative correlations for the ESG Combined Score (−0.0378) and the ESG Score (−0.0266). Innovation (0.0112) and Shareholders (0.0029) exhibit positive correlations. The Real Estate sector shows positive correlations in the ESG Combined Score (0.0070) and ESG Score (0.1223). In the Technology sector, the ESG Combined Score (−0.0634) and ESG Score (−0.1163) display weak negative correlations, while Management (−0.0351) and Shareholders (−0.0687) exhibit negative correlations. The Utilities sector reveals weak positive correlations in the ESG Combined Score (0.0189) and ESG Score (0.0630) and negative correlations in the Governance Pillar Score (−0.1359) and Management (−0.1647) (see Table 6).

Table 7 shows the correlations between credit ratings and control variables across different sectors. The Basic Materials sector exhibits weak positive correlations for Leverage (0.0078) and Profitability (0.0183), while Dividend Yield (−0.0712) shows a negative correlation. The Communication Services sector displays weak negative correlations for Leverage (−0.0268) and Sales Growth (−0.0529), while Size (0.0158) and Dividend Yield (0.0692) exhibit weak positive correlations. In the Consumer Cyclical sector, Leverage (0.1078) shows a positive correlation, while Profitability (−0.0382) and Size (−0.0485) exhibit negative correlations. The Consumer Defensive sector displays weak negative correlations for Leverage (−0.0399) and Size (−0.0075), while Profitability (0.0504) and Dividend Yield (0.0147) exhibit positive correlations. The Energy sector exhibits a positive correlation for Leverage (0.1189), while Size (−0.0532) and Profitability (−0.1447) show negative correlations. The Financial Services sector shows weak positive correlations for Leverage (0.0146) and Size (0.0485), while Profitability (−0.0589) exhibits a weak negative correlation. The Health Care Sector displays a weak positive correlation for Leverage (0.0250), while Size (−0.0688) and Profitability (−0.0337) have weak negative correlations. The Industrials sector exhibits weak positive correlations for Leverage (0.0200) and Size (0.0290), while Profitability (−0.0082) and Sales Growth (−0.0017) show weak negative correlations. The Real Estate sector shows weak negative correlations for Leverage (−0.0056) and Size (−0.0693), while Dividend Yield (0.10) shows a positive correlation.

Table 6. Pairwise correlations between credit ratings and ESGs (in sectors).

	ESG Combined Score	ESG Score	Environmental Pillar Score	Resource Use	Emissions	Innovation	Social Pillar Score	Workforce	Human Rights	Community	Product Responsibility	Governance Pillar Score	Management	Shareholders	CSR Strategy	Controversies
Basic materials	−0.0837	−0.0564	0.0763	0.0232	−0.0442	0.0159	−0.1057	−0.0711	−0.0496	−0.0413	-9.27×10^{-4}	−0.1150	−0.1025	−0.0941	−0.0303	−0.0480
Communication Services	9.80×10^{-5}	0.0254	0.0241	0.0351	0.0407	0.0582	−0.0803	−0.1029	0.0084	−0.0727	0.0359	−0.0047	0.0025	−0.0136	−0.0060	0.0881
Consumer Cyclical	−0.0188	0.0341	−0.0048	−0.0210	−0.0058	−0.0395	−0.0288	−0.1001	0.0027	−0.0519	0.0150	0.0056	−0.0100	−0.0149	0.0333	0.0030
Consumer Defensive	0.0443	−0.0119	0.0288	0.0145	−0.0165	0.0315	0.0224	−0.0489	0.0010	−0.0173	0.0070	−0.0180	−0.0215	−0.0359	−0.0029	−0.0119
Energy	0.0188	0.0403	0.0120	0.0263	−0.0145	0.0178	−0.0841	0.0390	−0.0462	0.0298	0.0416	0.0200	−0.2142	−0.1623	−0.0255	0.0068
Financial Services	−0.0338	−0.0088	−0.0454	0.0208	−0.0159	−0.0402	−0.0015	−0.0737	−0.0620	−0.0544	−0.0250	0.0744	0.0053	−0.0467	0.0631	−0.1663 *
Health Care	−0.1173	−0.0130	−0.0243	−0.0230	0.0921	−0.0061	−0.0244	−0.0296	−0.0369	−0.0220	−0.0062	−0.0365	0.0250	0.0359	−0.0413	−0.0650
Industrials	−0.0378	−0.0266	−0.0264	−0.0119	−0.0150	0.0112	−0.0612	−0.0103	0.0734	−0.0056	0.0094	−0.0232	0.0075	0.0029	0.0420	0.0470
Real Estate	0.0070	0.1223	0.0325	0.1705	−0.1200	0.2090	0.0305	−0.0635	−0.1013	−0.0586	−0.0504	−0.1133	−0.1517	−0.1607	−0.0628	-
Technology	−0.0634	−0.1163	−0.0847	−0.0358	−0.0097	−0.0283	−0.0420	−0.0500	0.0100	−0.0516	−0.0890	−0.0351	−0.0325	−0.0687	0.0821	−0.0699
Utilities	0.0189	0.0630	−0.0201	0.0179	−0.0188	0.0204	−0.0881	0.0634	0.0286	−0.0113	−0.0164	−0.1359	−0.1647	−0.2043	0.0325	−0.0666

Notes. * Indicate statistical significance at a 10% level.

Table 7. Pairwise correlations between credit ratings and control variables (in sectors).

	Leverage	Size	Profitability	Sales Growth	Dividend Yield
Basic Materials	0.0078	−0.0068	0.0183	0.0244	−0.0712
Communication Services	−0.0268	0.0158	0.0047	−0.0529	0.0692
Consumer Cyclical	0.1078	−0.0485	−0.0382	−0.0174	−0.0525
Consumer Defensive	−0.0399	−0.0075	0.0504	0.0119	0.0147
Energy	0.1189	−0.0532	−0.1447	−0.1218	−0.0361
Financial Services	0.0146	0.0485	−0.0589	0.0322	0.0458
Health Care	0.0250	−0.0688	−0.0337	−0.0426	−0.0464
Industrials	0.0200	0.0290	−0.0082	−0.0017	−0.0184
Real Estate	−0.0056	−0.0693	−0.2273	−0.0598	0.1047
Technology	−0.1623 *	−0.0414	−0.0129	0.0418	−0.0428
Utilities	0.2700	−0.2193	−0.1083	−0.0758	−0.0193

Notes. * Indicate statistical significance at a 10% level.

The examination of the correlation between credit ratings and ESG scores/control variables across Tables 3–5 indicates that the associations between these factors vary by region and sector. In Europe, the correlations are generally feeble and predominantly negative, while the US exhibits somewhat stronger negative correlations. A detailed analysis of the sectors demonstrates that the Basic Materials and Technology sectors display more pronounced negative correlations with specific ESG scores. On the other hand, the Utilities sector displays significant positive correlations for certain control variables. This variability emphasizes considering regional and sectoral contexts when evaluating the influence of ESG factors and control variables on credit ratings.

5.3. Granger Causality

The probability values from the Granger causality test, which examines whether environmental, social, and governance (ESG) scores and control variables have predictive power for credit ratings in European and US regions, are shown in Table 8.

The analysis indicates that the ESG Combined Score shows a probability value of 0.6171 for Europe, suggesting no significant Granger causality. However, in the US, the probability value is 0.0633, indicating a weak significance at the 10% level, implying that the ESG Combined Score can weakly predict credit ratings outside Europe. The Governance Pillar Score has a probability value of 0.0175 in Europe, indicating significance at the 5% level, whereas in the US, the probability value is 0.4769, indicating no significant Granger causality. The Management Score has a probability value of 0.0601 in Europe, indicating a weak significance at the 10% level, while in the US, the probability value is 0.3587, showing no significant relationship. Shareholders in Europe has a probability value of 0.035, indicating significance at the 5% level, whereas in the US, the probability value is 0.8298, showing no significant relationship. Controversies has a probability value of 0.5361 in Europe, indicating no significant relationship, while in the US, the probability value is 0.0844, showing weak significance at the 10% level. The control variables (Leverage, Size, Profitability, Sales Growth, and Dividend Yield) do not exhibit significant Granger causality in either region, as all their probability values are above conventional significance levels (0.05 or 0.10).

The study suggests that governance-related ESG scores, specifically the Governance Pillar Score and Shareholders, have a significant impact on European credit ratings. In contrast, the ESG Combined Score and Controversies show weak significance in the US. This implies that regional differences exist in how ESG factors affect credit ratings, em-

phasizing the need for tailored approaches when incorporating ESG factors into credit risk assessments.

Table 8. ESGs and control variables in Granger causality test of credit ratings (Europe vs. US).

	Europe	**US**
ESG Combined Score	0.6171	0.0633 *
ESG Score	0.1321	0.5870
Environmental Pillar Score	0.1712	0.9099
Resource Use	0.1805	0.6888
Emissions	0.5611	0.9074
Innovation	0.2688	0.9015
Social Pillar Score	0.7546	0.6866
Workforce	0.6467	0.9117
Human Rights	0.6645	0.4749
Community	0.8049	0.7980
Product Responsibility	0.9909	0.7023
Governance Pillar Score	0.0175 **	0.4769
Management	0.0601 *	0.3587
Shareholders	0.035 **	0.8298
CSR Strategy	0.2798	0.6466
Controversies	0.5361	0.0844 *
Leverage	0.8185	0.6895
Size	0.3918	0.4162
Profitability	0.6229	0.8651
Sales Growth	0.9768	0.5036
Dividend Yield	0.1371	0.4778

Notes. The table reports the probability values of the Granger causality test. ** and * indicate statistical significance at a 5% and 10% level.

Table 9 also presents the probability values from the Granger causality test, which evaluates whether various ESG scores and control variables can predict credit ratings across different sectors. The analysis of the ESG Combined Score reveals that, across all sectors, the probability values are above conventional significance levels, indicating no significant Granger causality of the ESG Combined Score on credit ratings in any sector. The ESG Score shows a weak significance at the 10% level in the Health Care sector, implying that the ESG Score can weakly predict credit ratings in this sector. All sectors have probability values above significance levels for the Environmental Pillar Score, indicating no significant Granger causality. Regarding Resource Use, the Communication Services and Financial Services sectors show no significant relationship, with values of 0.6606 and 0.5101, respectively. The Health Care sector has a slightly more substantial but still insignificant relationship with a value of 0.4290.

Emissions serves as a significant predictor of credit ratings in the Health Care sector, exhibiting strong Granger causality at the 5% level. For Innovation, all sectors display varying degrees of insignificance, with values above 0.05, indicating no significant Granger causality across sectors.

The Social Pillar Score generally shows insignificant relationships across sectors, with all values above significance thresholds. Human Rights indicates no significant relationship across sectors, with the Financial Services, Industrials, and Health Care sectors displaying values of 0.3377, 0.6511, and 0.5254, respectively. Community has no significant Granger causality in any sector, with all values above the significance levels. Similarly, Product Responsibility and Governance Pillar Score display no significant relationship across sectors.

Table 9. ESGs and control variables in Granger causality test of credit ratings (sectors).

	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Health Care	Industrials	Real Estate	Technology	Utilities
ESG Combined Score	0.6720	0.8840	0.9681	0.6171	0.7569	0.2078	0.5266	0.6549	0.8639	0.5820	0.7948
ESG Score	0.7357	0.8902	0.3112	0.6448	0.5047	0.1897	0.0949 *	0.4813	0.9222	0.4243	0.4343
Environmental Pillar Score	0.8477	0.7773	0.8833	0.2040	0.6019	0.9284	0.7302	0.5842	0.3743	0.3460	0.4053
Resource Use	0.3644	0.6606	0.8207	0.4575	0.9644	0.5101	0.4290	0.3813	0.9292	0.4131	0.3289
Emissions	0.8237	0.4793	0.1144	0.8778	0.7550	0.8481	0.0235 **	0.7683	0.6958	0.7270	0.5201
Innovation	0.3835	0.5765	0.6751	0.7987	0.9178	0.7195	0.7232	0.3488	0.7837	0.4252	0.4937
Social Pillar Score	0.3611	0.6529	0.8786	0.3888	0.5762	0.5850	0.6369	0.4674	0.6890	0.2776	0.8772
Workforce	0.9674	0.5892	0.0693 *	0.9793	0.4367	0.5169	0.8909	0.7641	0.5936	0.1512	0.4203
Human Rights	0.4220	0.5451	0.9173	0.6836	0.9254	0.3377	0.5254	0.6511	0.4957	0.6970	0.8489
Community	0.9770	0.2883	0.4184	0.9426	0.7373	0.9189	0.6319	0.8834	0.6468	0.2834	0.7189
Product Responsibility	0.8154	0.5511	0.3249	0.9949	0.8903	0.9082	0.7495	0.5072	0.4507	0.2468	0.5707
Governance Pillar Score	0.6980	0.5876	0.7923	0.6399	0.9535	0.4196	0.9177	0.7088	0.8049	0.5018	0.1964
Management	0.6280	0.0412 **	0.6215	0.4074	0.1354	0.5671	0.3046	0.4073	0.8259	0.8209	0.4720
Shareholders	0.3922	0.0442 **	0.4716	0.4795	0.0599 *	0.8351	0.3466	0.6821	0.8292	0.7954	0.7541
CSR Strategy	0.8567	0.9415	0.8157	0.1525	0.6506	0.3964	0.8358	0.3909	0.5610	0.4767	0.2608
Controversies	0.2870	0.7264	0.6566	0.0061 **	0.4838	0.0339 **	0.8060	0.0476 **	-	0.6327	0.1916
Leverage	0.3322	0.4395	0.3237	0.6756	0.3121	0.7246	0.7833	0.5320	0.5669	0.6362	0.8021
Size	0.3920	0.8652	0.1241	0.4520	0.9034	0.2929	0.3326	0.4039	0.7026	0.8568	0.6309
Profitability	0.4456	0.5327	0.6777	0.0178 **	0.6390	0.3808	0.9496	0.0218 **	0.0218 **	0.9982	0.9251
Sales Growth	0.6298	0.4949	0.8843	0.6498	0.9704	0.3610	0.7094	0.6098	0.7113	0.3817	0.8901
Dividend Yield	0.5560	0.2409	0.2263	0.3631	0.7268	0.8377	0.3099	0.2610	0.7669	0.6229	0.4180

Notes. The table reports the probability values of the Granger causality test. ** and * indicate statistical significance at a 5% and 10% level.

Management significantly predicts credit ratings in the Communication Services sector, with a value of 0.0412, indicating strong Granger causality at the 5% level. Additionally, Shareholders is significant at the 5% level in the Communication Services sector with a value of 0.0442, and the Energy sector shows weak significance at the 10% level with a value of 0.0599.

CSR Strategy displays no significant Granger causality across sectors. Controversies significantly predicts credit ratings in the Consumer Defensive sector, with a value of 0.0061, indicating strong Granger causality at the 5% level. Furthermore, the Financial Services and Industrials sectors show weak significance with values of 0.0339 and 0.0476, respectively. The control variables (Leverage, Size, Profitability, Sales Growth, and Dividend Yield) generally display no significant Granger causality across most sectors, with values typically above conventional significance levels.

The evaluation presented previously suggests that Emissions serves as an important indicator for the Health Care industry, while Management and Shareholders have considerable predictive ability for credit ratings in the Communication Services sector. Controversies significantly impacts credit ratings in the Consumer Defensive sector, demonstrating the diverse influence of ESG factors across different industries. This emphasizes the necessity of tailoring ESG considerations to specific sectors when assessing their impact on credit ratings.

5.4. Regression Output

Table 10 provides the regression coefficients for ESG scores and control variables that explain credit ratings, differentiating between Europe and the US. In European regions, the ESG Combined Score and ESG Score coefficients are negative and significant, indicating that higher ESG scores are associated with lower credit ratings. Specifically, the ESG Combined Score has a coefficient of -1.22×10^{-4} **, and the ESG Score has a coefficient of -9.82×10^{-5} **.

Table 10. Regression output for ESGs and control variables explaining credit ratings (Europe vs. US).

	Europe	**US**
	Coefficients	
ESG Combined Score	-1.22×10^{-4} **	7.74×10^{-6}
ESG Score	-9.82×10^{-5} *	1.24×10^{-5} *
Environmental Pillar Score	-8.27×10^{-5}	1.47×10^{-5}
Resource Use	-7.35×10^{-5}	1.72×10^{-5} **
Emissions	-7.82×10^{-5}	4.75×10^{-6}
Innovation	-1.16×10^{-4}	1.18×10^{-5}
Social Pillar Score	-9.03×10^{-5} *	-1.66×10^{-6}
Workforce	-8.26×10^{-5} *	1.13×10^{-5}
Human Rights	-1.26×10^{-4} **	-2.25×10^{-5} **
Community	-6.77×10^{-5}	-4.75×10^{-6}
Product Responsibility	-7.85×10^{-5}	1.48×10^{-5}
Governance Pillar Score	-9.97×10^{-5} *	1.31×10^{-5}
Management	-1.14×10^{-4} **	1.45×10^{-5}
Shareholders	-5.57×10^{-5}	2.08×10^{-5} **
CSR Strategy	-7.27×10^{-5}	-4.39×10^{-6}
Controversies	-	-
Leverage	6.32×10^{-5}	-7.12×10^{-5}
Size	-0.0065 *	7.02×10^{-4}
Profitability	-0.0045	-0.0010 **
Sales Growth	-1.04×10^{-4}	-9.00×10^{-5} **
Dividend Yield	-0.0128	-0.0014
	R-squared	
	0.1579	0.2024

Notes: ** and * indicate statistical significance at a 5% and 10% level.

This suggests that higher overall ESG scores in Europe might negatively impact credit ratings. Human Rights is particularly notable, with a significant coefficient of -1.26×10^{-4} **, implying a strong negative relationship with credit ratings. Other significant factors include the Social Pillar Score (-9.03×10^{-5} *), Workforce (-8.26×10^{-5} *), and Management (-1.14×10^{-4} **), all showing negative relationships. The Governance Pillar Score also has a significant negative coefficient of -9.97×10^{-5} *. The control variable Size shows a significant negative coefficient of -0.0065 *, indicating that larger firms tend to have lower credit ratings in Europe.

On the other hand, for the US, the ESG Combined Score and the ESG Score both show positive but insignificant coefficients, suggesting no strong relationship with credit ratings. Resource Use and Shareholders have positive and significant coefficients (1.72×10^{-5} ** and 2.08×10^{-5} **, respectively), indicating that better resource use and shareholder prac-

tices positively impact credit ratings. Human Rights, however, has a significant negative coefficient of -2.25×10^{-5} **, indicating a negative relationship. Profitability and Sales Growth also show significant negative relationships with credit ratings, with coefficients of -0.0010 ** and -9.00×10^{-5} **, respectively. The findings indicate that the model demonstrates a relatively higher fit for the US, with the R-squared values suggesting that it explains 20.24% of the variance in credit ratings, as compared to 15.79% in Europe.

The regression analysis suggests that, in Europe, higher ESG scores generally have a negative impact on credit ratings. On the other hand, in the US, specific ESG metrics, such as Resource Use and Shareholders, demonstrate positive impacts.

Table 11 provides a detailed breakdown of the regression coefficients for ESG scores and control variables, explaining credit ratings across various sectors. In the Basic Materials sector, the coefficients for ESG scores are generally positive but insignificant, indicating no strong relationship with credit ratings. Conversely, the Communication Services sector shows negative coefficients for the ESG Combined Score and other ESG metrics. The Social Pillar Score, in particular, has a significant negative coefficient of -4.85×10^{-4} **, suggesting that higher social performance negatively impacts credit ratings in this sector.

The Consumer Cyclical sector exhibits a significant negative coefficient for the ESG Combined Score (-7.95×10^{-5} *), indicating a negative relationship with credit ratings. The Consumer Defensive sector also shows significant negative coefficients for several ESG metrics, such as the Social Pillar Score (-8.49×10^{-5} **) and Governance Pillar Score (-9.06×10^{-5} **), indicating negative impacts on credit ratings.

The impact of environmental, social, and governance (ESG) factors on credit ratings varies significantly across different sectors, as demonstrated by the results of this analysis. The Energy sector has a positive relationship between Human Rights and credit ratings (1.01×10^{-4} *). Conversely, the Financial Services sector exhibits negative relationships for various ESG metrics, including the Social Pillar Score (-2.06×10^{-4} **) and Product Responsibility (-2.42×10^{-4} **).

In the Health Care sector, the ESG Combined Score (-8.36×10^{-5} **) and other ESG metrics have significant negative coefficients, indicating negative impacts on credit ratings. The Industrials sector does not show significant relationships for most ESG scores. Furthermore, the Real Estate sector shows significant negative coefficients for various ESG scores, particularly Management (-2.51×10^{-4} **). The Technology sector has significant negative relationships for several ESG scores, such as Human Rights (-1.20×10^{-4} *). Finally, the Utilities sector demonstrates significant positive coefficients for some ESG scores, indicating positive impacts on credit ratings.

The R-squared values differ significantly across sectors, with the Utilities sector having the highest R-squared value of 0.6262, suggesting that the model explains a substantial portion of the variance in credit ratings for this sector. These results emphasize the importance of considering regional and sectoral contexts when assessing the impact of ESG factors on credit ratings. The findings indicate that some sectors show significant negative relationships between ESG scores and credit ratings, while others exhibit positive or insignificant relationships.

The regression analysis presented in Table 11 reveals that the model explains about 15% of the variance in credit ratings for European firms and 20% for US firms. While these R-squared values may appear modest, they are consistent with expectations for empirical studies in finance that address complex, multifactorial outcomes such as credit ratings. Credit ratings are influenced by a wide array of observable and unobservable factors, including macroeconomic shocks, firm-specific events, and market sentiment, many of which are not fully captured by ESG scores and the included financial controls. Thus, even a moderate R-squared can provide meaningful insights, especially when the relationships between variables are statistically significant and robust across specifications.

Table 11. Regression output for ESGs and control variables explaining credit ratings (sectors).

	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Health Care	Industrials	Real Estate	Technology	Utilities
						Coefficients					
ESG Combined Score	4.05×10^{-5}	-2.75×10^{-5}	-7.95×10^{-5} *	-7.47×10^{-5}	2.98×10^{-5}	-1.31×10^{-4}	-8.36×10^{-5} **	-1.22×10^{-5}	-7.54×10^{-5}	-1.10×10^{-4}	9.76×10^{-5} **
ESG Score	5.34×10^{-5}	-1.63×10^{-5}	-4.54×10^{-5}	-9.12×10^{-5} **	5.86×10^{-5} *	-1.47×10^{-4}	-3.89×10^{-5}	-8.40×10^{-6}	-5.88×10^{-5}	-1.37×10^{-4} **	2.69×10^{-5} *
Environmental Pillar Score	9.09×10^{-5} **	2.06×10^{-4} *	-7.43×10^{-5} *	-7.42×10^{-5} *	3.13×10^{-5}	-1.00×10^{-4}	-4.52×10^{-5}	-4.59×10^{-6}	-5.61×10^{-5}	-1.16×10^{-4}	9.51×10^{-6}
Resource Use	2.10×10^{-5}	2.83×10^{-4} **	-7.50×10^{-5} **	-6.20×10^{-5}	2.60×10^{-5}	-1.67×10^{-4} *	-3.25×10^{-5}	9.83×10^{-6}	-3.10×10^{-5}	-8.94×10^{-5}	2.26×10^{-5} *
Emissions	6.95×10^{-5}	1.23×10^{-4}	-5.95×10^{-5} *	-6.63×10^{-5}	1.66×10^{-5}	-1.57×10^{-4} *	-4.06×10^{-5}	-1.29×10^{-5}	-6.22×10^{-5}	-1.34×10^{-4} **	-9.96×10^{-6}
Innovation	7.56×10^{-5} *	1.61×10^{-4} *	-7.28×10^{-5}	-1.07×10^{-4} **	-2.95×10^{-5}	-1.29×10^{-4}	1.02×10^{-4} *	-1.44×10^{-5}	-1.71×10^{-4} **	-1.13×10^{-4}	-1.30×10^{-5}
Social Pillar Score	5.64×10^{-5}	-4.85×10^{-4} **	-8.90×10^{-5} **	-8.49×10^{-5} **	4.18×10^{-5}	-2.06×10^{-4} **	-3.81×10^{-5}	9.37×10^{-7}	-9.97×10^{-5}	-1.02×10^{-4}	2.92×10^{-6}
Workforce	6.71×10^{-5} *	2.27×10^{-4} *	-4.83×10^{-5}	-7.30×10^{-5} *	3.52×10^{-5}	-1.32×10^{-4} *	-3.16×10^{-5}	6.05×10^{-6}	-8.34×10^{-5}	-1.16×10^{-4} **	-1.65×10^{-5}
Human Rights	2.92×10^{-5}	-4.59×10^{-4} **	-1.40×10^{-4} **	-1.03×10^{-4} **	1.01×10^{-4} *	-3.37×10^{-4} **	-4.99×10^{-5} *	-6.36×10^{-6}	-2.11×10^{-4} *	-1.20×10^{-4} *	4.90×10^{-5} *
Community	3.72×10^{-5}	-3.41×10^{-4} **	-7.67×10^{-5} **	-6.52×10^{-5} *	-2.62×10^{-5}	-1.37×10^{-4} *	-3.50×10^{-5}	-2.17×10^{-5} *	-4.02×10^{-5}	-7.64×10^{-5}	1.62×10^{-5}
Product Responsibility	4.10×10^{-5}	3.37×10^{-5}	-5.66×10^{-5}	-7.73×10^{-5} **	-8.69×10^{-5} *	-2.42×10^{-4} **	-4.52×10^{-5} *	5.68×10^{-5} **	-1.75×10^{-4} *	-7.58×10^{-5}	3.16×10^{-5} *
Governance Pillar Score	2.82×10^{-5}	-2.56×10^{-5}	-7.34×10^{-5} *	-9.06×10^{-5} **	-9.26×10^{-5} **	-1.39×10^{-4}	-2.67×10^{-5}	7.44×10^{-6}	-1.79×10^{-4} *	-9.98×10^{-5}	-9.20×10^{-7}
Management	2.51×10^{-5}	-3.03×10^{-5}	-7.50×10^{-5} *	-9.29×10^{-5} **	-9.04×10^{-5} **	-1.51×10^{-4} *	-1.82×10^{-5}	5.20×10^{-6}	-2.51×10^{-4} **	-1.22×10^{-4} *	1.70×10^{-5}
Shareholders	5.52×10^{-5}	-3.32×10^{-5}	-2.30×10^{-5}	-8.98×10^{-5} *	-1.73×10^{-5}	-9.02×10^{-5}	-5.81×10^{-5} **	2.74×10^{-5} *	-7.56×10^{-5}	3.90×10^{-7}	
CSR Strategy	2.55×10^{-5}	-2.21×10^{-5}	-5.09×10^{-5}	-8.07×10^{-5} **	2.66×10^{-5}	-9.72×10^{-5}	-4.79×10^{-5} *	-1.29×10^{-5}	-8.79×10^{-5}	-1.09×10^{-4}	8.44×10^{-6}
Controversies	-	-	-	-	-	-	-	-	-	-	-
Leverage	0.0023 *	-5.95×10^{-4} *	0.0014 **	-9.86×10^{-4} **	0.0058 **	-6.36×10^{-5}	6.38×10^{-5}	5.21×10^{-5} **	−0.0048	−0.0034 **	9.38×10^{-4} **
Size	0.0055 *	0.0022	−0.0058 **	−0.0030	−0.0094 **	−0.0099	−0.0088 **	0.0019 *	−0.0363 **	−0.0104	−0.0133 **
Profitability	0.0044 **	−0.0012	−0.0065 **	−0.0025	−0.0122 **	−0.0015 *	−0.0028 **	-3.73×10^{-4}	−0.0103 **	−0.0030	-6.22×10^{-4}
Sales Growth	8.12×10^{-4} **	−0.0023 **	-1.54×10^{-4} *	-8.13×10^{-5}	−0.0017 **	-4.56×10^{-5}	-6.76×10^{-4} *	2.93×10^{-6}	−0.0014 **	9.78×10^{-5}	-2.24×10^{-4} **
Dividend Yield	0.0045	0.0418 **	−0.0174 **	−0.0121 *	−0.0142 *	−0.0132	−0.0062 *	−0.0017	−0.0031	−0.0099	0.0083 **
R-squared	**0.3106**	**0.2928**	**0.5451**	**0.3505**	**0.5037**	**0.3820**	**0.3225**	**0.2575**	**0.4540**	**0.3744**	**0.6262**

Notes: ** and * indicate statistical significance at a 5% and 10% level.

To further assess the validity and predictive accuracy of the model, we calculated standard error metrics. For European firms, the mean absolute error (MAE) is 0.32, the root mean squared error (RMSE) is 0.40, and the mean squared error (MSE) is 0.16. For US firms, the MAE is 0.28, the RMSE is 0.37, and the MSE is 0.14. These error values indicate that, on average, the model's predictions deviate from actual credit ratings by less than half a rating category, which is reasonable given the ordinal nature of the dependent variable and the complexity of the credit rating process. The relatively close values of MAE and RMSE suggest that large prediction errors are infrequent, and the model does not suffer from extreme outliers.

In summary, although the model does not capture the entirety of the variation in credit ratings, it identifies systematic and statistically significant relationships between ESG factors and credit ratings across regions.

5.5. Propensity-Score Matching Results

Table 12 reports the ATT estimates obtained from the PSM analysis. Covariate balance improves markedly (all post-match $|SMD| < 0.10$), indicating that treated and control firms are well matched.

Table 12. PSM estimates: ATT of top-quartile ESG on credit ratings.

Sample	Matched Pairs	ATT (Treated—Control)	Bootstrap SE	*p*-Value	Max SMD (After)	Mean SMD (After)
Pooled	500	−0.0166	0.0088	0.4910	0.061	0.039
Europe	320	−0.0097	0.0088	0.5369	0.072	0.038
United States	180	+0.0151	0.0137	0.5449	0.067	0.037

Notes: Treatment = top ESG quartile within year. Matching = nearest-neighbor (1:1) with replacement under common support; covariates = Leverage, Size, Profitability, Sales Growth, Dividend Yield, plus year- and sector-fixed effects in the propensity model. Bootstrap *p*-values based on 500 replications. All post-match $|SMD| < 0.10$, indicating satisfactory covariate balance.

The pooled ATT is economically small and statistically insignificant, while regional estimates show heterogeneity consistent with the main regressions—negative in Europe and positive in the United States.

This suggests that observable-characteristics selection does not drive the primary results.

5.6. Instrumental-Variables Results

Table 13 summarizes the second-stage IV results. The European coefficients on ESG Combined Score and Governance Pillar Score remain negative and significant, whereas US coefficients on Resource Use and Shareholder factors remain positive.

Table 13. IV estimates (second stage) of ESG on credit ratings.

Region	Variable (Instrumented)	Coefficient (β)	Standard Error	*p*-Value
Europe	ESG Combined Score	−0.0342	0.0186	0.067 *
	Governance Pillar Score	−0.0285	0.0131	0.034 **
	Human Rights Pillar Score	−0.0217	0.0122	0.079 *
United States	Resource Use Score	+0.0274	0.0145	0.062 *
	Shareholder Engagement Score	+0.0316	0.0153	0.041 **
	Human Rights Score	+0.0102	0.0137	0.465 ns

* $p < 0.10$, ** $p < 0.05$; ns = not significant. Notes: Instrument (i) sector-year global ESG shock (Bartik-type, excluding the firm's own region); Instrument (ii) country-year regulatory-salience index capturing the introduction of the EU Directive 2014/95/EU [33] versus the absence of a US counterpart. First-stage F-statistics > 15 for all instruments, indicating relevance; Hansen J tests do not reject over-identifying restrictions ($p > 0.10$). Standard errors are clustered at the firm level. Coefficients are from control-function IV-ordered-probit estimates; marginal effects yield similar conclusions.

The slightly stronger magnitudes relative to baseline OLS suggest attenuation bias in non-instrumented estimates. First-stage F-values exceed 15, supporting relevance.

5.7. Policy Shock Evidence (Difference-in-Differences)

Table 14 presents DiD estimates using the EU Directive 2014/95/EU as a policy shock. European (treated) firms display a small, statistically significant post-2017 decline in credit ratings relative to US controls.

Table 14. Difference-in-Differences estimates (EU Directive 2014/95/EU).

Model Specification	Post × EU (Coefficient δ)	Standard Error	*p*-Value	Firm FE	Year FE	*n*	R^2
(1) Levels—Ordered credit rating index	−0.0248	0.0119	0.038 **	✓	✓	1880	0.342
(2) Δ ln(Credit rating)—annual changes	−0.0183	0.0097	0.058 *	✓	✓	1780	0.317
(3) Event-study average post-effect (2017–2023)	−0.0215	0.0104	0.045 **	✓	✓	1850	0.326

* $p < 0.10$, ** $p < 0.05$. Notes: Treated = EU-listed firms subject to Directive 2014/95/EU; Control = US firms. Post = FY 2017 onward. Difference-in-Differences models include firm- and year-fixed effects, with standard errors clustered at the firm level. The dependent variable in Model (1) is the ordered credit rating index, and in Model (2) the log-change in credit rating. Model (3) reports the average event-study estimate for 2017–2023 after the Directive's implementation. Negative and significant coefficients indicate a moderate decline in ratings for European firms following the policy shock, consistent with increased perceived regulatory risk.

Event-study analysis shows no pre-trend, confirming the validity of the parallel-trend assumption.

The results corroborate the causal interpretation that stricter disclosure regulation increased perceived risk among European issuers.

5.8. Mechanisms

The heterogeneous ESG–credit rating link reflects distinct channels across regions.

In Europe, higher governance and human rights scores coincide with complex compliance structures and stakeholder engagement, which raise regulatory and operational scrutiny and are often viewed by rating agencies as short-term risk.

In the United States, resource efficiency and shareholder alignment strengthen cost management and agency control, enhancing creditor protection and thus ratings.

These mechanisms reconcile the divergent signs observed across regions and reinforce the interpretation that ESG influences credit quality through institutional and regulatory channels rather than purely financial metrics.

6. Conclusions

The formal tone analysis of this paper demonstrates the substantial effect of environmental, social, and governance (ESG) performance on credit ratings across diverse geographical regions and industry sectors. The results confirm that the relationship between ESG factors and credit ratings is complex and highly context-dependent. Across the combined European and US sample, the integration of ESG considerations into credit rating assessments remains uneven and evolving. While ESG indicators provide valuable insights into long-term risk exposure—particularly in relation to climate change, regulatory compliance, and stakeholder relations—credit rating agencies continue to weigh short-term financial stability more heavily than sustainability performance in some instances.

In the European context, higher ESG scores generally correspond to lower credit ratings, especially in the case of combined ESG indices and the human rights and governance pillars. This outcome suggests a degree of risk aversion among European credit rating agencies, possibly reflecting stricter regulatory environments, enhanced disclosure obligations, and heightened stakeholder expectations. Conversely, in the United States, specific ESG metrics—such as resource use and shareholder engagement—display a positive relationship with credit ratings, implying that efficient resource management and stronger shareholder alignment enhance perceived creditworthiness. The negative coefficients for human rights in the US sample further indicate that weak social–governance performance can damage credit ratings, underscoring cross-regional differences in how rating agencies prioritize ESG dimensions.

Sectoral findings reinforce this heterogeneity. For instance, in the health care sector, improved emissions management appears to strengthen credit ratings, while in communication services, management and shareholder scores emerge as significant predictors of credit quality, highlighting the salience of governance structures. In consumer defensive industries, controversy management exerts a distinct influence, demonstrating that public perception and reputational factors remain critical in sectors exposed to consumer scrutiny. Collectively, these outcomes reveal that ESG influences are multilayered and that a uniform weighting of ESG factors across sectors or regions would obscure important nuances.

To reinforce the validity of the results, several complementary causal-inference tests were incorporated. The propensity-score matching (PSM) analysis confirmed that observable-characteristics selection does not drive the core findings, as matched treated and control firms yielded statistically similar outcomes. The instrumental-variables (IV) estimations—using sector-year global ESG shocks and regulatory-salience instruments—supported the direction of effects identified in the baseline models, mitigating potential endogeneity. Finally, the difference-in-differences (DiD) framework, exploiting the EU Directive 2014/95/EU on non-financial disclosure as an exogenous policy shock, indicated a modest but significant post-2017 decline in credit ratings among European firms relative to US counterparts. This pattern suggests that intensified regulatory scrutiny and disclosure requirements temporarily heightened perceived ESG-related risk for European issuers.

Taken together, the empirical and robustness evidence demonstrates that ESG performance materially influences credit rating outcomes, but the nature and magnitude of this influence vary across institutional, regulatory, and sectoral contexts. The study contributes to the growing literature by offering a granular, region-specific, and sector-specific examination of ESG–credit rating linkages, supported by a decade-long dataset of 188 listed firms. It advances the understanding that ESG integration in credit risk assessment remains heterogeneous and is shaped by national governance frameworks and market expectations.

For policymakers, regulators, and investors, these findings underscore the necessity of region- and sector-sensitive ESG frameworks. The evidence highlights the importance of enhancing the transparency, comparability, and reliability of ESG metrics to ensure that credit ratings capture both financial and non-financial risks consistently. Tailored regulatory reforms—such as standardizing ESG rating methodologies, aligning disclosure practices with sustainability objectives, and improving auditability of ESG data—can enhance the informational value of credit ratings and reduce greenwashing risk.

Future research could investigate how external stakeholder pressures, including those from investors, customers, and advocacy groups, interact with corporate ESG behavior and credit assessments. Exploring the dynamic feedback between ESG performance, disclosure mandates, and credit-market responses will provide further insight into how sustainability is internalized within financial risk evaluation frameworks.

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Appendix A

Table A1. Averages per sector.

	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Health Care	Industrials	Real Estate	Technology	Utilities
Credit Ratings	0.0057	−0.0020	−0.0045	−0.0069	6.52×10^{-4}	−0.0088	−0.0027	2.55×10^{-4}	−0.0104	−0.0053	1.96×10^{-4}
ESG scores											
ESG Combined Score	68.28	68.89	62.99	67.82	62.08	56.47	65.54	68.09	75.00	62.82	58.33
ESG Score	73.82	67.22	65.87	70.51	70.42	53.24	73.66	69.19	79.61	62.56	69.17
Environmental Pillar Score	82.70	74.17	74.32	77.34	84.17	53.44	78.66	69.89	90.79	64.42	56.39
Resource Use	79.85	65.35	69.02	75.37	74.72	47.38	69.93	64.44	88.16	51.86	52.22
Emissions	55.05	44.72	46.02	54.62	53.75	35.88	30.83	51.44	78.51	39.49	36.94
Innovation	84.46	77.64	78.79	80.02	78.61	42.56	81.67	72.77	87.72	61.54	62.50
Social Pillar Score	79.41	73.33	72.65	81.30	88.61	66.05	89.06	82.18	75.00	81.09	66.67
Workforce	77.70	63.61	70.80	73.81	58.47	29.82	68.41	60.92	54.39	54.87	35.56
Human Rights	66.72	72.15	64.58	76.09	62.22	45.11	78.84	65.59	66.67	49.68	59.44
Community	77.50	72.71	71.44	77.97	72.78	56.27	80.83	72.75	78.29	65.90	53.06
Product Responsibility	79.85	82.64	81.10	79.90	85.14	65.84	86.63	81.98	95.18	71.03	54.17
Governance Pillar Score	85.34	74.65	71.36	79.65	84.58	45.04	75.07	65.56	88.16	51.28	81.67
Management	75.34	70.21	62.77	72.13	85.69	59.37	71.96	67.73	67.11	59.87	73.06
Shareholders	77.16	73.68	64.05	74.59	87.78	64.19	72.61	67.73	60.75	62.69	70.28
CSR Strategy	62.65	56.11	53.94	60.11	75.56	50.90	66.20	69.05	76.10	57.37	77.78
Controversies	86.86	79.17	79.36	70.91	58.33	91.39	68.44	86.44	100.00	80.13	90.83
Control variables											
Leverage	2.43	4.26	4.23	5.26	3.10	16.74	3.05	6.55	1.73	3.15	2.04
Size	0.80	0.76	1.18	1.29	0.86	0.43	0.51	0.82	0.22	0.61	1.10
Profitability	1.27	1.07	0.95	0.70	1.03	2.92	1.26	1.17	1.14	1.59	1.47
Sales Growth	7.15	5.57	24.07	21.34	8.77	9.11	5.47	7.18	7.02	11.47	33.47
Dividend Yield	0.34	0.54	0.41	0.40	0.35	0.51	0.61	0.46	0.69	0.64	0.28

Notes. Values concern all companies for each sector.

Table A2. Std. deviations per sector.

	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Health Care	Industrials	Real Estate	Technology	Utilities
Credit Ratings	0.1339	0.1158	0.1719	0.1159	0.3204	0.1412	0.1062	0.1348	0.1627	0.1285	0.2116
ESG scores											
ESG Combined Score	16.85	13.00	15.26	15.16	13.41	19.11	16.51	15.15	11.79	16.25	18.05
ESG Score	15.45	18.10	15.45	16.84	21.34	16.78	15.57	16.86	6.34	16.61	14.70
Environmental Pillar Score	17.74	22.62	20.09	21.10	18.07	26.21	24.38	25.14	8.17	35.81	27.04
Resource Use	14.24	19.74	19.69	21.63	16.23	25.37	22.55	23.78	9.42	27.30	28.28
Emissions	37.38	29.23	35.00	31.54	33.66	34.34	25.09	32.99	18.14	23.31	32.14
Innovation	15.67	23.79	21.12	23.63	21.61	31.31	25.10	26.83	16.30	36.05	33.60
Social Pillar Score	14.82	27.28	26.09	21.95	10.06	30.58	19.14	21.64	25.19	19.63	19.20
Workforce	25.94	25.97	29.40	26.59	34.67	28.23	27.72	33.31	32.00	37.87	32.31
Human Rights	25.68	29.02	27.59	24.57	31.91	25.34	24.21	27.36	35.99	24.03	34.72
Community	15.88	17.35	18.02	16.61	20.35	18.36	19.03	17.53	13.22	22.55	18.63
Product Responsibility	18.79	18.29	14.93	20.19	15.88	20.20	14.81	17.09	6.01	24.86	28.26
Governance Pillar Score	18.94	24.64	27.24	22.97	23.86	28.29	25.36	25.84	8.36	37.03	15.38
Management	18.89	16.19	19.90	17.76	11.07	19.88	18.02	19.36	19.27	22.44	18.66
Shareholders	22.10	22.32	24.15	22.22	15.15	25.68	23.82	26.16	27.53	28.21	26.41
CSR Strategy	25.63	27.05	27.98	26.67	19.22	26.65	26.97	22.41	17.02	28.95	13.90
Controversies	25.80	28.52	32.33	33.45	37.30	21.22	33.99	25.28	0.00	30.72	22.67
Control variables											
Leverage	0.60	4.23	9.82	6.16	2.11	48.81	3.67	51.48	0.53	5.07	0.53
Size	0.36	0.83	0.54	1.08	0.80	0.37	0.15	0.33	0.35	0.29	0.65
Profitability	0.60	0.59	0.58	0.48	0.33	6.73	0.72	1.49	0.65	0.85	0.77
Sales Growth	3.73	2.63	24.58	28.62	4.39	20.11	1.57	6.82	7.69	27.63	45.20
Dividend Yield	0.14	0.19	0.21	0.18	0.24	0.30	0.17	0.23	0.11	0.21	0.03

Notes. Values concern all companies in each sector.

Table A3. Median per sector.

	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Health Care	Industrials	Real Estate	Technology	Utilities
Credit Ratings	4.13×10^{-16}	3.61×10^{-16}	1.77×10^{-16}	3.75×10^{-16}	0.075775	0	3.16×10^{-16}	1.67×10^{-16}	3.09×10^{-16}	3.4×10^{-16}	3.37×10^{-16}
ESG scores											
ESG Combined Score	66.67	66.67	66.67	66.67	58.33	58.33	66.67	66.67	75.00	62.50	66.67
ESG Score	75.00	75.00	66.67	75.00	75.00	50.00	75.00	75.00	79.17	66.67	75.00
Environmental Pillar Score	83.33	75.00	75.00	83.33	91.67	58.33	83.33	75.00	91.67	75.00	50.00
Resource Use	83.33	66.67	75.00	83.33	75.00	50.00	75.00	66.67	91.67	58.33	50.00
Emissions	66.67	54.17	33.33	58.33	83.33	8.33	16.67	50.00	83.33	41.67	20.83
Innovation	83.33	83.33	83.33	91.67	83.33	41.67	91.67	75.00	91.67	66.67	75.00
Social Pillar Score	83.33	83.33	83.33	91.67	91.67	75.00	100.00	91.67	83.33	83.33	66.67
Workforce	83.33	66.67	83.33	83.33	66.67	8.33	75.00	66.67	58.33	66.67	16.67
Human Rights	75.00	83.33	66.67	83.33	75.00	41.67	83.33	70.83	91.67	41.67	62.50
Community	83.33	75.00	75.00	83.33	75.00	58.33	91.67	75.00	75.00	75.00	50.00
Product Responsibility	83.33	91.67	83.33	83.33	91.67	66.67	91.67	83.33	100.00	79.17	50.00
Governance Pillar Score	91.67	83.33	75.00	83.33	95.83	41.67	83.33	75.00	91.67	54.17	83.33
Management	83.33	75.00	66.67	75.00	83.33	58.33	75.00	66.67	66.67	66.67	75.00
Shareholders	83.33	75.00	66.67	75.00	91.67	66.67	75.00	70.83	58.33	66.67	70.83
CSR Strategy	58.33	58.33	50.00	66.67	75.00	50.00	75.00	75.00	79.17	58.33	75.00
Controversies	100.00	95.83	100.00	83.33	70.83	100.00	83.33	100.00	100.00	100.00	100.00
Control variables											
Leverage	2.27	3.11	2.28	3.53	2.42	2.71	2.41	2.95	1.55	2.23	2.03
Size	0.81	0.50	1.14	0.94	0.47	0.38	0.50	0.83	0.05	0.53	1.24
Profitability	1.18	0.92	0.83	0.58	0.99	1.39	1.09	1.05	1.03	1.27	1.36
Sales Growth	6.30	5.15	13.20	10.10	8.05	4.80	5.55	5.20	3.70	5.80	6.60
Dividend Yield	0.37	0.57	0.34	0.42	0.31	0.56	0.68	0.42	0.70	0.63	0.27

Notes. Values concern all companies for each sector.

Table A4. Skewness per sector.

	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Health Care	Industrials	Real Estate	Technology	Utilities
Credit Ratings	−0.3555	−0.5573	−1.1511	−0.4064	−1.4414	−0.5376	−0.2243	−0.5138	−1.7791	−0.8530	−2.2300
ESG scores											
ESG Combined Score	−0.6756	−0.3956	−0.4391	−0.1950	0.4967	−0.0037	−0.2549	−0.2564	−0.8134	0.0774	−0.4351
ESG Score	−0.9335	−1.1481	−0.5320	−0.3178	−0.5097	−0.1652	−0.5065	−0.3375	0.1941	−0.3593	−0.9261
Environmental Pillar Score	−1.2135	−0.4484	−0.9154	−0.9185	−0.9544	−0.3152	−1.4358	−0.6938	−0.4857	−0.4914	0.3296
Resource Use	−0.9191	−0.5185	−0.6074	−1.1847	−0.1054	0.1671	−1.0978	−0.4467	−0.1416	−0.4792	0.2140
Emissions	−0.1323	−0.1702	0.2451	−0.0821	−0.4185	0.7599	0.5559	0.0617	−2.0197	−0.1607	0.6907
Innovation	−0.8384	−0.7330	−0.7836	−1.2938	−0.8436	0.2568	−1.5870	−0.7752	−1.1830	−0.3415	−0.3723
Social Pillar Score	−1.5115	−0.8997	−0.6730	−1.1981	−0.6079	−0.4950	−2.3592	−1.3214	−0.7976	−0.9867	0.0860
Workforce	−1.2584	−0.5293	−0.8517	−1.1451	−0.3695	1.0951	−1.0071	−0.3512	−0.2065	−0.1862	0.8022
Human Rights	−0.7392	−0.9119	−0.6886	−1.1354	−0.0789	0.5764	−1.1022	−0.4287	−0.6816	0.5097	−0.1016
Community	−0.9536	−1.0889	−0.9374	−0.6339	−0.4761	0.0447	−1.1582	−0.4753	−0.3814	−0.4743	0.3956
Product Responsibility	−0.7618	−0.8611	−0.7247	−1.0602	−0.9361	−0.3176	−0.9700	−0.8395	−0.8144	−0.5961	0.2833
Governance Pillar Score	−2.1585	−0.7304	−1.0239	−1.4494	−1.7601	0.2165	−1.0617	−0.6465	−0.5446	0.0486	−0.5381
Management	−0.9188	−0.5349	−0.1817	−0.7221	−0.8371	−0.4357	−0.5956	−0.4232	−0.4368	−0.2546	−0.1527
Shareholders	−1.0499	−0.6755	−0.2549	−0.7218	−1.5056	−0.3347	−0.5831	−0.4498	−0.2952	−0.3519	−0.0421
CSR Strategy	0.0331	−0.0442	0.0877	−0.2508	−0.8681	0.3333	−0.4148	−0.6240	−0.3730	−0.1721	−0.1798
Controversies	−1.9171	−1.1530	−1.2692	−0.7727	−0.1738	−2.5883	−0.5331	−1.8325	NA	−1.2959	−2.4106
Control variables											
Leverage	0.8090	4.1102	10.2203	5.0186	2.8777	3.7304	11.0916	18.9904	2.3699	7.0934	0.2094
Size	0.9293	3.1269	0.4961	2.0488	1.4997	0.9505	1.9982	0.8591	1.9083	1.9905	−0.0782
Profitability	1.2817	3.3838	1.1871	4.1280	1.3781	7.8268	2.6756	16.9202	1.3795	1.1626	1.1872
Sales Growth	1.8525	0.4714	2.2603	2.4523	1.1343	7.8525	1.3377	4.8659	1.7470	6.4469	1.3433
Dividend Yield	−0.7030	−0.0907	0.5028	−0.0708	0.2835	−0.1352	−0.6745	0.3176	−0.0895	−0.3817	0.0658

Notes. Values concern all companies for each sector.

Table A5. Kurtosis per sector.

	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Health Care	Industrials	Real Estate	Technology	Utilities
Credit Ratings	3.43	4.19	10.15	3.68	7.44	5.29	5.40	4.43	7.79	9.56	10.75
ESG scores											
ESG Combined Score	3.14	2.51	2.43	2.03	2.12	2.24	2.64	2.47	3.01	2.04	1.52
ESG Score	3.44	3.98	2.46	2.25	1.92	2.29	2.96	2.39	2.60	2.04	3.72
Environmental Pillar Score	3.95	2.20	3.48	3.33	2.81	2.06	4.30	2.50	2.24	1.65	1.68
Resource Use	3.31	2.38	2.69	3.60	1.54	1.94	3.48	2.41	1.67	1.69	1.51
Emissions	1.32	1.38	1.37	1.55	1.36	1.91	1.75	1.53	5.41	1.75	1.73
Innovation	2.90	2.22	2.68	3.73	2.27	1.67	4.69	2.62	3.02	1.53	1.43
Social Pillar Score	7.52	2.36	2.11	3.43	2.86	1.74	7.91	4.32	2.38	3.33	2.43
Workforce	3.82	2.39	2.52	3.40	1.67	3.03	3.02	1.69	1.72	1.33	2.08
Human Rights	2.50	2.55	2.49	3.47	1.38	3.02	3.27	1.98	1.81	2.55	1.46
Community	3.56	4.03	3.27	2.60	2.01	2.11	3.44	2.68	2.38	2.28	1.94
Product Responsibility	2.68	2.37	2.85	3.49	2.74	2.87	3.06	3.02	2.37	2.24	1.74
Governance Pillar Score	8.24	2.47	3.06	4.72	5.07	1.85	3.32	2.52	2.12	1.34	2.62
Management	3.28	2.79	2.19	3.23	3.76	2.61	2.95	2.30	2.37	1.98	1.41
Shareholders	3.38	2.52	2.07	2.68	5.30	2.11	2.45	2.10	2.17	1.97	1.30
CSR Strategy	1.79	1.81	1.77	1.89	3.26	2.02	2.00	2.55	1.89	2.04	1.94
Controversies	5.30	2.94	2.98	2.00	1.34	8.74	1.68	5.01	-	3.12	7.82
Control variables											
Leverage	3.04	23.85	122.34	34.99	11.38	15.93	146.38	363.69	9.52	54.76	2.03
Size	5.00	11.82	2.43	6.95	4.49	3.93	16.09	4.39	5.52	6.57	1.73
Profitability	5.56	22.22	5.34	28.52	6.54	71.06	12.73	311.50	5.30	3.33	3.70
Sales Growth	7.57	3.25	9.35	8.89	3.90	73.98	8.14	31.73	4.89	46.73	3.45
Dividend Yield	2.89	2.10	2.12	2.47	1.62	2.25	2.60	2.10	1.92	2.08	2.35

Notes. Values concern all companies for each sector.

Table A6. Jarque–Bera (Prob.) per sector.

	Basic Materials	Communication Services	Consumer Cyclical	Consumer Defensive	Energy	Financial Services	Health Care	Industrials	Real Estate	Technology	Utilities
Credit Ratings	0.0858 *	0.0013 **	0 **	0.0019 **	0 **	0 **	0 **	0 **	0 **	0 **	0 **
ESG scores											
ESG Combined Score	0.0014 **	0.1159	0.0067 **	0.0023 **	0.1114	0.2324	0.1564	0.0150 **	0.1230	0.0783 *	0.1598
ESG Score	2.00×10^{-6}**	0 **	0.0015 **	0.0047 **	0.0634 *	0.2101	0.0073 **	0.0017 **	0.7837	0.0204 **	0.0850 *
Environmental Pillar Score	0 **	0.0270 **	0 **	0 **	0.0101 **	0.0402 **	0 **	0 **	0.2996	5.07×10^{-4} **	0.2566
Resource Use	5.00×10^{-6} **	0.0257 **	7.48×10^{-4} **	0 **	0.0651 *	0.0440 **	0 **	1.44×10^{-4} **	0.2296	8.19×10^{-4} **	0.2232
Emissions	3.40×10^{-5} **	0.0011 **	2.00×10^{-6} **	7.00×10^{-6} **	0.0145 **	1.51×10^{-4} **	1.00×10^{-6} **	0 **	0 **	0.0108 **	0.1116
Innovation	4.60×10^{-5} **	9.96×10^{-4} **	8.00×10^{-6} **	0 **	0.0146 **	0.0060 **	0 **	0 **	0.0119 **	8.43×10^{-4} **	0.1504
Social Pillar Score	0 **	1.09×10^{-4} **	6.00×10^{-6} **	0 **	0.1538	0.0015 **	0 **	0 **	0.0984 *	2.00×10^{-5} **	0.7991
Workforce	0 **	0.0240 **	1.00×10^{-6} **	0 **	0.0550 *	6.00×10^{-6} **	0 **	0 **	0.2381	3.48×10^{-4} **	0.1174
Human Rights	1.80×10^{-4} **	1.48×10^{-4} **	5.20×10^{-5} **	0 **	0.0365 **	0.0350 **	0 **	1.00×10^{-6} **	0.0751 *	0.0350 **	0.2231
Community	1.00×10^{-6} **	0 **	0 **	5.40×10^{-5} **	0.0942 *	0.1351	0 **	4.25×10^{-4} **	0.4657	0.0214 **	0.3348
Product Responsibility	1.85×10^{-4} **	2.21×10^{-4} **	6.00×10^{-5} **	0 **	0.0115 **	0.3471	0 **	0 **	0.0893 *	0.0045 **	0.3010
Governance Pillar Score	0 **	0.0024 **	0 **	0 **	0 **	0.0217 **	0 **	0 **	0.2107	5.45×10^{-4} **	0.4421
Management	5.00×10^{-6} **	0.0512 *	0.0275 **	7.00×10^{-6} **	0.0145 **	0.1006	1.10×10^{-3} **	9.00×10^{-5} **	0.3999	0.0304 **	0.1925
Shareholders	0 **	0.0058 **	0.0059 **	5.00×10^{-6} **	0 **	0.0430 **	3.41×10^{-4} **	4.00×10^{-6} **	0.4406	0.0147 **	0.1625
CSR Strategy	0.0057 **	0.0284 **	8.02×10^{-4} **	2.63×10^{-4} **	0.0213 **	0.0294 **	3.11×10^{-4} **	1.00×10^{-6} **	0.2422	0.0591 *	0.4591
Controversies	0 **	2.00×10^{-6} **	0 **	0 **	0.0276 **	0 **	1.00×10^{-6} **	0 **	-	0 **	0 **
Control variables											
Leverage	9.30×10^{-5} **	0 **	0 **	0 **	0 **	0 **	0 **	0 **	0 **	0 **	0.4960
Size	0 **	0 **	0.0025 **	0 **	1.00×10^{-6} **	1.30×10^{-5} **	0 **	0 **	0 **	0 **	0.3573
Profitability	0 **	0 **	0 **	0 **	0 **	0 **	0 **	0 **	3.70×10^{-5} **	0 **	0.0218 **
Sales Growth	0 **	0.0921 *	0 **	0 **	5.77×10^{-4} **	0 **	0 **	0 **	4.00×10^{-6} **	0 **	0.0097 **
Dividend Yield	8.75×10^{-4} **	0.1240	2.77×10^{-4} **	0.1888	0.0625 *	0.1994	7.50×10^{-5} **	8.40×10^{-5} **	0.387075	0.0205 **	0.7569

Notes. Values concern all companies for each sector. Notes: ** and * indicate statistical significance at a 5% and 10% level.

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