Asymmetric Impact of ESG on Credit Risk

Abstract

The paper exploits a panel quantile regression technique to uncover the asymmetric impact of material Environmental, Social, and governance (ESG) ratings on conditional quantiles of US corporate bond spreads. This work contributes to the literature by 1) comparing the ESG-bond spreads relationship between the heavily polluting sample (comprising of bonds belonging to heavily emitting companies) and the lightly polluting sample (comprising of bonds belonging to lightly emitting companies) 2) breaking down the effect of composite ESG ratings into effects of individual weighted pillars of ESG on bond spreads, 3) studying the impact of ESG on bond spreads across quantiles of bond spreads. The novel split-panel jackknife bias-correction approach has been employed to alleviate the bias arising from having a small T relative to N. Three main findings emerge from the analyses. First, improvements in ESG ratings lead to lower spreads due to the risk mitigation effect for brown firms. On the other hand, for green firms, ESG rating upgrades lead to higher spreads. Next, E pillar is the strongest pillar in determining the bond spreads of brown firms. All pillars E, S, and G pillars are important determinants of bond spreads for green firms. Lastly, improvements in ESG ratings are heterogeneous across quantiles.

1 Introduction

Climate risk is broadly categorized into two categories namely, physical risk and transition risk. Physical risks stem from changes in the climate resulting in damage to productive assets. Transition risks stem from the transition to a low-carbon economy. The drivers of physical risks include increasing temperatures, rising sea levels, etc. And, the drivers for transition risks include changes in the policies, technological change geared towards a low-carbon economy, and the overall sentiment of stakeholders (investors, customers, employees, governments, etc.) towards climate change. Climate risk is caused by rising global temperatures that are a result of accumulated greenhouse gases (GHGs) in the atmosphere. According to the United Nations, at the moment the world is heading for a rise in excess of 3°C this century. In response to the climate crisis, the UN has laid out 17 Sustainable

Development Goals (SDGs) - these goals are an urgent call for action by all nations of the world.

In light of this urgent call for action and increasing climate risk, sustainability has gained immense traction over the past two decades. For businesses, it is hard to think about sustainability without thinking about ESG. The acronym 'ESG' stands for Environmental (E), Social (S), and Governance (G) which provides investors with an understanding of how a business is doing with respect to various sustainability metrics. Therefore, ESG can be thought of as a means of evaluating a company's sustainability. Other stakeholders including customers, employees, regulators, and governments are also paying attention to the ESG credentials of businesses.

It is well-documented that climate risks are reflected in the capital structure and the cost of capital of firms. Ginglinger and Moreau (2019) find that post-2015 (Paris climate agreement - implementation of TCFD) high climate risk firms found it hard to increase their leverage levels compared to low climate risk firms. It is also established that climate risk reflects in the cost of capital - in the form of increased cost of debt and equity (Chava, 2014; Kling et al., 2021; Balvers et al., 2017). ESG too is found to be priced in the capital markets (Ng and Rezaee, 2015; Apergis et al., 2022; Berg et al., 2022).

Theoretically, the direction of the impact of ESG performance on bond spreads can go either way - positive or negative. As per the agency theory, the management is interested in their reputation and self-image and therefore, may over-invest in ESG activities to boost stakeholder support, improve social influence or conceal misconduct of the organization. This results in overspending on pro-ESG activities thereby causing the wastage of an organization's limited resources. Over-investment in ESG activities due to the principal-agent problem may eventually cause distrust among stakeholders translating into increased risk and therefore, higher bond spreads. Trade-off theory also suggests that firms investing in ESG initiatives beyond a point may cause organizations to divert their resources away from economically beneficial investment avenues. This may lead to lower cash flows and hence, higher risks causing the bond investors to demand compensation for those risks. On the other hand, investment in ESG activities may also have a reduction effect on bond spreads. Stakeholder theory argues that engaging in ESG activities builds long-term trust with stakeholders. When trust improves, the firm accumulates reputation capital which in turn helps companies to withstand adverse shocks by making the company more resilient. Next, regulatory risks[1] are also easier to deal with for organizations that perform well in ESG.

Most recent literature in this area finds a negative relationship between ESG performance and credit spreads (Li et al., 2024; Li and Adriaens, 2024; Lian et al., 2023; Barth et al., 2022; Apergis et al., 2022; Atif and Ali, 2021; Oikonomou et al., 2014). However, the relationship between ESG and bond spreads could be much more nuanced and vary across companies. Gull et al. (2022) and Van Hoang et al. (2023) point out that the sector to which a company belongs significantly affects its commitment towards sustainability development goals. Companies operating in sectors that pollute more are also more likely to be subject to more stringent regulations corresponding to higher environmental compliance costs. Qian et al. (2023) find that government inspection (which is more likely to be carried out in polluting industries) has a pronounced influence on the environmental investments of a firm. These findings suggest that perceptions of firms, customers, investors, governments and other stakeholders regarding ESG issues may differ across companies depending on their sector. Given this, it is plausible that the direction of the impact of ESG performance on bond spreads may not be negative or equally strong for brown (heavily-emitting) and green (lightly-emitting) firms. Therefore, this paper seeks to study the differences in the effect of ESG on credit risk between brown and green firms.

As bond spreads carry information about the credit risk associated with the bond, analyzing how ESG interacts with bond spreads at different points along bond spreads' distribution may reveal differences in how bond spreads vary with ESG at different levels of credit risk. Li and Adriaens (2024) suggest one must exercise caution and consider the differences in the effects of individual ESG pillars on bond spreads. Hence, in this paper,

[1] Climate change regulations have the greatest impact on companies, particularly energy-intensive ones (Lian et al., 2023)

the relationship between the composite ESG score and weighted E, S, and G pillar and bond spreads is modeled using the novel technique called the method of moments panel quantile regression approach (developed by Machado and Silva (2019)). Split-panel jackknife bias correction has been applied to alleviate the bias arising from a small T dimension.

This paper contributes to the existing literature in multiple ways. One, it analyzes the impact of ESG on bond spreads for brown (heavily-emitting) and green (lightly-emitting) firms. Two, the paper analyzes the contribution of individual pillars of the ESG score to changes in the bond spreads for brown and green firms separately. Three, weighted E, S, and G pillars are considered to ensure that the pillars are comparable across industries and the results are generalizable. Finally, the impact of ESG and its pillars on the different points along bond spreads' distribution is analyzed to account for the heterogeneity in the effect of ESG across bond spreads' distribution.

2 Literature Review

First, the literature review considers studies capturing the relationship between climate risk and the cost of capital in general, followed by studies pertaining to the impact of ESG performance on bond spreads.

2.1 Climate risk and cost of capital

To understand how ESG performance (a proxy for firms' efforts towards alleviating climate risks) affects bond spreads, it is important to first understand how climate risks impact firms' cost of capital. Ginglinger and Moreau (2019) study the impact of physical climate risk rating on capital structure and cost of capital. They find that physical climate risk results in lower leverage post-2015 (Paris climate agreement). They attribute this reduction in leverage to an increase in operational costs and expected distress costs resulting from potential climate risks[2]. They find that the reduction in leverage post-2015 is primarily observed

[2] The loss could stem from damage to assets owned by firms because of extreme climate events or reduction in firms' asset values

for firms with low CSR performance. This suggests that firms with higher CSR performance are better prepared to withstand climate risks. Kim et al. (2015) investigate the impact of carbon risk on the cost of equity. They find that carbon intensity[3], a proxy for carbon risk, is positively associated with the cost of equity. Chava (2014) cover a wide variety of factors (environmental strengths and concerns) that proxy for environmental risks to investigate the impact of a firm's environmental profile on its cost of capital. The main findings of the paper are twofold. One, firms with climate change concerns exhibit a notably higher cost of equity as well as a higher cost of debt capital. Two, the cost of equity and debt capital is not significantly different for firms with environmental strengths compared to firms without these strengths. Kling et al. (2021) analyze the effects of climate-related vulnerability on firms' cost of capital and access to finance in high and low-climate-risk countries. They construct a climate vulnerability index to instrument for climate vulnerability (to avoid potential endogeneity issues) to gauge the impact of climate vulnerability on firms' cost of debt and equity and access to capital. They find that firms in climate-vulnerable countries have higher financing costs (cost of debt and equity) and, climate-vulnerable countries are financially more constrained i.e. have relatively less access to capital. Chen and Silva Gao (2012) study the relationship between climate risk and measures of the cost of capital. They show that after controlling for a range of factors, climate risk is positively associated with the implied cost of equity and bond yield to maturity spread (a measure of the cost of debt). Morrone et al. (2022) investigate the impact of environmental disclosure on the cost of debt and cost of capital in the energy sector. They show that the impact of environmental disclosure is negative on the cost of debt and the cost of capital. And, the impact of carbon intensity is positive on the cost of debt and cost of capital.

2.2 ESG, firm risk and bond spreads

Recently, the literature on the linkage between ESG performance and credit spreads has gained momentum.

[3] measured by dividing total carbon emissions by sales

Li et al. (2024) study the effect of ESG performance on bond financing costs for different types of creditors in China. They find that the national interbank bond market and the qualified institutional investors require a lower rate of return on their bond holdings when a firm has good ESG performance. They mention that this may be because creditors such as the national interbank bond market and qualified institutional investors are increasingly looking to have more of pro-ESG investments in their portfolios. On the other hand, domestic legal and natural persons and other institutional investors may not be driven by ESG as their motives are gaining short-term returns as opposed to long-run value-based investing. Li et al. (2024) also discuss possible transmission mechanisms in the ESG-bond spreads relationship. They find that the bond cost reduction effect is achieved by improving ESG performance because of enhanced information disclosure quality and reputation. Oikonomou et al. (2014) explore the impact of different dimensions of corporate social performance on the pricing of corporate debt. Their overall findings indicate that good corporate social performance is rewarded in the form of lower bond yield spreads and poor performance is penalized in the form of higher bond yield spreads. Atif and Ali (2021) investigate if ESG disclosure is linked to firms' default risk and credit default swap spread. Their findings suggest that ESG disclosure increases Merton's distance to default (a measure of default risk) indicating a reduction in default risk and decreases credit default swap spread. They highlight the negative effect of ESG disclosure on the default risk and credit default swap spread that exists only for mature and older firms. Atif and Ali (2021) point out that ESG disclosure affects the default risk and credit default swap spread via improved profitability and reduced performance variability influence. Good ESG credentials also help alleviate concerns regarding potential liabilities arising from operations and legal risks (Apergis et al., 2022). Barth et al. (2022) argue that the association between ESG and firm risks translates into the valuation of credit risk or a firm's probability of default. They highlight that if companies doing well in ESG exhibit higher and more stable cash flows that result in higher asset values, better ESG performers should have lower probabilities of default and hence, lower credit spreads. Lian et al. (2023) examine the relationship between ESG and corporate bond spreads and find that better ESG leads to lower bond spreads. Their mechanism analyses reveal that better ESG lowers corporate financial risk, improves corporate information transparency, and reduces debt agency issues that lead to a reduction in bond spreads. Their analysis also points out that the effect of ESG on bond spreads is more prominent in non-state enterprises, enterprises in poor macroeconomic environments, and enterprises in regions with higher degree of marketization. There is some evidence related to the existence of differences in the ESG-credit risk relationship among industry sectors. Yang et al. (2021) finds that the risk mitigation effect of ESG on corporate credit spreads is more pronounced for non-high-polluting energy-consumption companies. Li and Adriaens (2024) explore the ESG-bond spread relationship for different AEC (Architecture, Engineering, and Construction) companies and non-AEC companies. They further categorize the companies in four sub-sectors on the basis of the nature of their business. Their findings indicate that on average, companies exhibit a 10-basis point benefit resulting from ESG improvement. They further highlight that the effects of ESG on bond pricing may vary across sectors.

This research aims to

Does the impact of ESG vary across heavily emitting and lightly emitting firms? Do all pillars of ESG affect bond spreads in the same way? Do certain pillars serve as more significant determinants of bond spreads for brown firms compared to green firms? Does ESG affect the bond spreads consistently across the distribution of bond spreads?

3 Data

3.1 Data collection and variable description

Data used in this analysis pertains to corporate bonds issued by companies incorporated in the USA and active (not matured) as of 2nd March 2023. The panel includes 2922 bond-year observations. The bonds included in the sample are fixed-rate, senior, bullet, unsecured, and conventional (non-green). Green bonds are excluded from the analysis as they were very few and have different properties. Data employed in this analysis is primarily retrieved from Bloomberg. The period considered is from December 2017 to December 2022. The data is annual which implies that 6 years for a cross-section of 487 bonds is analyzed. All missing values and observations with value '0' are excluded from the sample. Observations with abnormal values (such as bonds that reported negative spreads in one or more years) were also excluded from the final sample. The summary statistics and the sectoral distribution of the bonds included in the sample are reported in Table 1. The response variable (ln Lead Spread) is the natural log of one-month ahead bond ask spreads which are essentially the differential between the offering yield to maturity of the corporate bond over the yield of a treasury bond of similar maturity. Since the distribution of credit spread is typically positively skewed, the natural logarithm of the bond spread is employed as the dependent variable in the analysis.

The control variables include bond characteristics and firm characteristics. The bond-level control variables used are Rating - Moody's credit rating (assigned to each bond at the time of issuance), lnISSUESIZE - the size of the issue, and Maturity (in years) - the maturity of bond. Moody's rating scale ranges from Aaa to C. Each rating has been assigned a numerical value from 1 to 19 - where 1 represents the lowest rating and 19 represents the highest rating. The table reflects a minimum value of 3 indicating that any bonds that were assigned a rating below 3 were dropped while cleaning the data. The average rating is 11.848, indicating that on average, companies are assigned higher credit ratings. The natural logarithm of the issue size has been used. The issue The mean value of Maturity is 24.107 indicating that the sample largely consists of very long-term bonds.

The firm-level controls comprise ROA - return on assets ratio (measure of profitability), ICR - interest coverage ratio (measure of the ability of a company to honor its repayment obligations), Growth - sales growth (measure of a company's growth), LEV - total debt to total assets ratio (measure of how leveraged the business is), and ln Mkt Cap - natural logarithm of market capitalization of a company (measure of the size of a company).

Year-end values (values as of 31st December of each year) for all independent variables are considered, while bond spread values are taken from one month after the year-end (values as of 31st January of the next year). This has been done to allow sufficient time for the market to account for the independent variables in their decision making and to alleviate any concerns around endogeneity.

Table 2 presents the correlations between the variables employed in the analysis. It can be noticed that the bond spread is correlated with all control variables in the expected way. It is positively correlated with maturity and leverage, while it is negatively correlated with rating, profitability, interest coverage ratio, growth, size and size of the issue. Interestingly, the bond spread is also negatively correlated with the composite ESG score, which indicates that bonds belonging to companies with high ESG scores exhibit lower spreads. However, for the individual weighted pillar scores, it is observed that while bond spreads exhibit a negative correlation with the weighted S and G pillars, it has a positive correlation with the weighted E pillar.

3.2 ESG Ratings (Scores)

Bloomberg's ESG scores and their individual pillars i.e. E, S, and G are the variables of interest in this analysis. Bloomberg assigns these ESG scores to companies annually, assessing how effectively they manage financially material ESG issues. Since financial materiality varies across industries, Bloomberg assigns weights to various sub-issues based on their relevance to the industry group.

To calculate the composite ESG scores, Bloomberg uses a weighted shifted power-mean (p-mean) methodology. First, sub-issue weights and scores are aggregated to determine the issue scores. Then, these issue scores are again weighted according to their industry materiality and combined, to arrive at the pillar scores. Finally, the pillar weights and scores are aggregated to derive the overall composite ESG score.

Investors can make more informed investment decisions based on ESG performance when financial materiality is considered (Madison and Schiehll, 2021). The composite ESG scores provided by Bloomberg are computed after taking into account pillar weights and therefore financial materiality. While, the individual pillar scores reported by Bloomberg are not comparable across industries unless adjusted (using pillar weights) to reflect their financial materiality to the industry group. So, in this study, pillar weights and pillar scores are combined using the weighted shifted p-mean methodology used by Bloomberg to arrive at the weighted pillar scores. And, composite ESG score is employed as it is reported. The summary statistics for these scores are reported in Table 1.

3.3 Sample selection and descriptive statistics

In this study, three samples are analysed. The first sample analysed is the full sample (consisting of 2,922 bond-year observations) as described in section 3.1. The full sample is divided into two sub-samples i.e. brown (heavily polluting) and green (less polluting) based on emission intensity (Classification-1). Emission intensity has been widely used in the literature to measure how green the company is (In et al., 2017; Garvey et al., 2018; Bauer et al., 2022). Emission intensity is computed as the ratio of total CO2 equivalent emissions in a year normalized by the revenues of the company in that year. These emission intensities are then averaged across all years to arrive at the average emission intensity for each company. Following Garvey et al. (2018), based on the average emission intensity, the bonds with an emission intensity above the 70th percentile are categorized as brown and, bonds with an emission intensity below the 30th percentile are categorized as green. The summary statistics for these two sub-samples are presented in Table 3.

Table 4 reports two correlation matrices - one for the brown sample (Panel A) and one for green sample (Panel B). The correlation coefficient between bond spread and composite ESG score is negative for brown sample while it is positive for green sample. Similarly, the correlation coefficient between bond spread and the weighted E pillar score is negative for brown sample and positive for green sample. This result implies that brown firms with high composite ESG score and weighted E pillar score tend to have lower spreads while the opposite is true for green firms.

On the other hand, both brown and green samples exhibit a positive correlation coefficient between bond spreads and weighted S pillar scores. Finally, the correlation coefficient between bond spreads and the weighted G pillar score is positive for brown sample and negative for the green sample.

4 Empirical Methodology

4.1 Panel fixed effects model

To uncover the impact of ESG on bond spreads for different samples, this study employs a panel data fixed effect estimation technique. The panel data fixed effect estimation allows to quantify the change in bond spreads (within variation) caused by changes in the ESG ratings while taking into account the effect any observed as well as time-invariant unobserved bond characteristics. Due to the fact that bond effects are taken into account, any unobserved characteristics relating to the industry or the firm (to which the bond belongs) are also accounted for. Apart from the bond-level fixed effects, time dummies are also included in the model to account for any time (year) related shocks that may have occurred. Hausman's specification test has also been conducted to select if the random effects or the fixed effects model fits the data better. The results of the Hausman test indicate that a fixed effects model is the appropriate choice. Therefore, the following fixed effects models are estimated:

$$
\begin{aligned}
\ln(\mathrm{LeadSpread})_{\mathrm{i(t+1)}} = \beta_0 + \beta_1 \mathrm{CompositeESGScore}_{\mathrm{it}} + \beta_2 \mathrm{ROA}_{\mathrm{jt}} + \beta_3 \mathrm{ICR}_{\mathrm{it}} + \beta_4 \mathrm{Growth}_{\mathrm{it}} \\
+ \beta_5 \mathrm{LEV}_{\mathrm{it}} + \beta_6 \ln(\mathrm{MktCap})_{\mathrm{it}} + \alpha_{\mathrm{i}} + \mu_{\mathrm{t}} + \epsilon_{\mathrm{it}}
\end{aligned}
\tag{1}
$$

$$
\begin{aligned}
\ln(\mathrm{LeadSpread})_{\mathrm{i(t+1)}} = \beta_0 + \beta_1 \mathrm{WeightedEPillar}_{\mathrm{it}} + \beta_2 \mathrm{WeightedSPillar}_{\mathrm{it}} + \beta_3 \mathrm{WeightedGPillar}_{\mathrm{it}} \\
+ \beta_4 \mathrm{ROA}_{\mathrm{it}} + \beta_5 \mathrm{ICR}_{\mathrm{it}} + \beta_6 \mathrm{Growth}_{\mathrm{it}} \beta_7 \mathrm{LEV}_{\mathrm{it}} + \beta_8 \ln(\mathrm{MktCap})_{\mathrm{it}} + \alpha_{\mathrm{i}} + \mu_{\mathrm{t}} + \epsilon_{\mathrm{it}}
\end{aligned}
\tag{2}
$$

In the equations above, α_i and μ_t denote bond-specific and time-specific fixed effects, respectively. The dependent variable i.e. $ln(LeadSpread)_{i(t+1)}$ denotes the lead spread measured one month ahead of the measurement date of the right hand side variables.

4.2 Panel quantile fixed effect model

The longitudinal fixed effects models described by equations 1 and 2 fail to capture the differences in the relationship between bond spreads and ESG across the different segments of the distribution of bond spreads. This is problematic if the distribution of the response variable (bond spreads in this case) is not normal[4]. Quantile regression on the other hand, makes no assumptions about the distribution of the response variable. Quantile regression enables estimation of the impact of the explanatory variables on the response variable across various points (quantiles) along the distribution of the latter. So, panel quantile regression estimation was done to model the impact of ESG on bond spreads at different quantiles (ranging from 10th quantile to 90th quantile). This paper makes use of the Method of Moments Panel Quantile Regression (with individual fixed effects) estimator developed by Machado and Silva (2019). This estimator estimates the conditional quantiles for a location-scale model which can be expressed as follows:

$$\mathrm{Y_{it}} = \alpha_\mathrm{i} + \mathrm{X'_{it}}\beta + (\rho_\mathrm{i} + \mathrm{D_{it}}\theta)\epsilon_\mathrm{it} \tag{3}$$

Y_{it} denotes the ln Lead Spread. α_i and ρ_i denote bond specific effects for every bond 'i'. X_{it} denotes the vector of the time-varying independent variables. D_{it} denotes a vector of known differentiable transformations of X_{it}. $Pr(\rho_i + D_{it}\theta > 0 = 1)$. ϵ_{it} is i.i.d across 'i' and 't', satisfies the moment conditions and is independent of X_{it} statistically. Next, equation 3 can be used to express conditional quantiles as follows:

$$\mathrm{Q_Y}(\tau|\mathrm{X_{it}}) = (\alpha_\mathrm{i} + \rho_\mathrm{i}\mathrm{q}(\tau)) + \mathrm{X'_{it}}\beta + \mathrm{D'_{it}}\theta\mathrm{q}(\tau) \tag{4}$$

[4]Jarque-Bera test was conducted to check for normality of the distribution of bond spreads. The results indicated that the bond spread distribution is not normal.

Using equation 4, the impact of ESG on bond spreads is assessed across the conditional distribution of the latter. An important feature of this model is that the quantile-τ fixed effects, representing the time-invariant bond characteristics, captured by $\alpha_i + \rho_i q(\tau)$ have different effects on different segments of the conditional distribution of bond spreads. Split-panel jackknife bias correction proposed by Dhaene and Jochmans (2015) has been utilized to alleviate the concerns about bias caused by incidental parameters problem. Implementation of this technique also enables credible inference when bias arising from moderate values of T is present (Machado and Silva, 2019).

5 Empirical Results

In the ensuing tables, pooled OLS fixed effect results are presented alongside the results of panel quantile fixed effects model results based on model 4 after implementing split-panel jackknife bias correction. This enables clear comparison between panel OLS FE results and results across quantiles. Column (1) presents results based on model 1 if impact of composite ESG on bond spreads is studied, and model 2 if impact of ESG's individual weighted pillars is being studied.

Table 5 presents the impact of ESG on bond spreads for the full sample. The pooled OLS fixed effects regression resuts in column (1) show negative (but insignificant) impact of the composite ESG rating on lead bond spread. However, panel quantile regression results show evidence of a negative and significant impact of ESG ratings on bond spreads in the first three columns (corresponsing to the 10th, 20th and the 30th quantiles). This result implies that at lower values of spreads (spreads below 30th percentile), higher ESG ratings of the company are associated with low risk associated with bonds thereby, causing the investors to accept lower returns on bonds resulting in lower spreads. The bonds having lower spreads are more likely to be from larger corporations that are highly capitalized which signals that, ESG ratings are a matter of consideration for companies having a large market share. This result is plausible as Zumente and Lāce (2021) point out that larger companies typically have more resources to formulate sustainability policies, leading to higher ESG scores. If that is the case, it is also more likely to reduce information asymmetry about larger corporations compared to their smaller peers - which reflects in Table 5 results.

Table 1: Summary statistics: Full Sample

Panel A: Descriptive Statistics					
Variable	Obs	Mean	Std. dev.	Min	Max
Weighted E Pillar	2,922	0.792	0.229	0.176	1.293
Weighted S Pillar	2,922	0.742	0.174	0.192	1.418
Weighted G Pillar	2,922	0.890	0.109	0.530	1.153
Composite ESG Score	2,922	4.912	0.885	1.580	7.470
ln Lead Spread	2,922	5.023	0.544	1.751	7.628
Maturity (in years)	2,922	24.107	8.292	5.000	50.000
Rating	2,922	11.848	1.951	3.000	19.000
ROA	2,922	3.044	6.548	-30.946	32.666
ICR	2,922	4.698	8.956	-34.583	74.169
Growth	2,922	2.309	21.460	-64.863	233.828
LEV	2,922	36.125	15.335	9.894	243.874
ln ISSUESIZE	2,922	18.650	1.941	14.255	22.572
ln Mkt Cap	2,922	10.856	1.131	6.414	14.874

Panel B: Sectoral Distribution		
	Frequency	%
Sector		
Communications	222	8%
Consumer Discretionary	204	7%
Consumer Staples	174	6%
Healthcare	216	7%
Industrials	1,488	51%
Materials	144	5%
Oil&Gas	144	5%
Real Estate	30	1%
Technology	126	4%
Utilities	174	6%
Total	2,922	100%

Notes: This table presents the summary statistics of bond-year observations for the full sample. The sample period is from December 2017 to December 2022 and the frequency of observations is annual. The sample comprises 147 US corporate bonds. Panel A presents the descriptive statistics for all the variables for the full sample. Panel B presents the sectoral distribution of the bond-year observations.

Table 2: Correlation matrix: Full sample

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	Maturity (in years)	1												
2	Rating	-0.0377	1											
3	ROA	0.3497	0.2996	1										
4	ICR	0.2817	0.419	0.6492	1									
5	Growth	0.1412	0.0235	0.3031	0.1991	1								
6	LEV	0.1982	-0.2922	0.2246	-0.0632	-0.0296	1							
7	ln Mkt Cap	0.0311	0.494	0.1967	0.2177	0.0161	-0.0841	1						
8	ln ISSUESIZE	0.5997	0.0155	0.4775	0.3544	0.165	0.2834	0.1578	1					
9	Composite ESG Score	-0.2956	0.1983	-0.1924	-0.0862	-0.0424	-0.2744	0.0974	-0.3543	1				
10	Weighted E Pillar	-0.0145	-0.0941	-0.0282	-0.0176	0.0252	0.0177	-0.1689	-0.1731	0.4963	1			
11	Weighted S Pillar	-0.0816	0.1803	0.0249	0.0103	-0.0027	-0.0978	0.2758	0.0614	0.251	-0.5936	1		
12	Weighted G Pillar	-0.3475	0.2701	-0.3215	-0.1313	-0.1342	-0.3612	0.0987	-0.352	0.2976	-0.2932	0.0918	1	
13	ln Lead Spread	0.0798	-0.5778	-0.4208	-0.3343	-0.1068	0.051	-0.4357	-0.2446	-0.0464	0.1108	-0.1469	-0.0848	1

Notes: This table presents the correlation matrices for variables employed in the study. The sample comprises 147 US corporate bonds observed annually from December 2017 to December 2022.

Table 3: Summary statistics: Brown and Green sub-samples (based on classification-1)

Panel A: Descriptive Statistics

Classification-1: based on emissions' intensity (EI)

	Brown Sample: High EI (sample with bonds above 70th percentile of EI)					Green Sample: Low EI (sample with bonds below 30th percentile of EI)				
Variable	Obs	Mean	Std. dev.	Min	Max	Obs	Mean	Std. dev.	Min	Max
Weighted E Pillar	366	1.058	0.124	0.590	1.293	396	0.672	0.271	0.251	1.193
Weighted S Pillar	366	0.564	0.138	0.192	1.065	396	0.804	0.167	0.527	1.418
Weighted G Pillar	366	0.843	0.123	0.643	1.134	396	0.886	0.092	0.730	1.028
Composite ESG Score	366	5.099	0.770	2.270	6.830	396	4.611	0.819	3.210	6.350
ln Lead Spread	366	5.055	0.449	3.731	6.533	396	4.870	0.605	2.110	6.149
Maturity (in years)	366	27.049	6.756	12.000	50.000	396	29.455	9.792	10.000	50.000
Rating	366	11.180	1.468	6.000	14.000	396	11.667	2.172	8.000	15.000
ROA	366	4.711	8.200	-30.946	29.718	396	4.348	5.813	-8.310	16.570
ICR	366	4.438	7.349	-24.658	74.169	396	6.377	9.330	-11.117	33.762
Growth	366	8.112	28.004	-64.863	233.828	396	2.960	21.061	-40.269	104.899
LEV	366	38.551	9.337	12.868	58.355	396	39.383	14.086	9.894	60.988
ln ISSUESIZE	366	19.017	1.601	14.745	21.129	396	20.267	1.052	16.090	22.572
ln Mkt Cap	366	10.430	0.922	7.528	11.989	396	11.369	0.793	9.379	12.712
E Weight	366	45.176	2.699	38.460	50.000	396	28.445	11.099	11.110	45.450
S Weight	366	26.073	6.435	12.500	38.460	396	40.749	9.625	27.270	55.560
G Weight	366	28.745	4.103	23.080	37.500	396	30.801	2.460	27.270	33.330

Panel B: Sectoral Distribution

Brown Sample			Green Sample		
Sector	Frequency	%	Sector	Frequency	%
Industrials	90	25%	Communications	30	8%
Materials	72	20%	Consumer Discretionary	66	17%
Oil&Gas	96	26%	Consumer Staples	18	5%
Utilities	108	30%	Healthcare	90	23%
Total	366	100%	Industrials	126	32%
			Technology	66	17%
			Total	396	100%

Notes: This table presents the summary statistics of bond-year observations for the brown sample (sample with bonds belonging to companies with emission intensity above 70th percentile) and green sample (sample with bonds belonging to companies with emission intensity below 30th percentile). The sample period is from December 2017 to December 2022 and the frequency of observations is annual. The brown sample comprises 61 US corporate bonds and the green sample comprises 66 US corporate bonds. Panel A presents the descriptive statistics for all the variables for the full sample. Panel B presents the sectoral distribution of the bond-year observations.

Table 4: Correlation matrices for Brown and Green samples

Panel A: Correlation matrix for Brown sample

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	Maturity	1.000												
2	Rating	-0.047	1.000											
3	ROA	0.073	0.312	1.000										
4	ICR	0.090	0.330	0.666	1.000									
5	Growth	0.056	-0.111	0.277	0.284	1.000								
6	LEV	-0.020	-0.077	-0.372	-0.382	-0.007	1.000							
7	ln Mkt Cap	-0.378	0.637	0.347	0.208	-0.027	0.134	1.000						
8	ln ISSUESIZE	0.734	-0.011	0.127	0.125	0.044	0.037	-0.209	1.000					
9	Composite ESG Score	-0.443	-0.050	-0.143	-0.162	0.098	0.247	0.200	-0.321	1.000				
10	Weighted E Pillar	-0.454	-0.088	-0.096	-0.075	0.085	0.229	0.270	-0.306	0.879	1.000			
11	Weighted S Pillar	-0.178	0.235	0.007	0.018	0.083	0.237	0.316	-0.184	0.455	0.303	1.000		
12	Weighted G Pillar	0.101	-0.235	-0.093	-0.160	-0.050	-0.161	-0.363	0.121	-0.101	-0.206	-0.831	1.000	
13	ln Lead Spread	0.446	-0.572	-0.298	-0.154	0.038	0.143	-0.645	0.242	-0.127	-0.118	-0.237	0.222	1

Panel B: Corrrelation matrix for Green sample

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)
1	Maturity	1.000												
2	Rating	-0.349	1.000											
3	ROA	-0.164	0.399	1.000										
4	ICR	-0.104	0.344	0.590	1.000									
5	Growth	-0.035	0.087	0.305	0.261	1.000								
6	LEV	0.142	-0.609	-0.144	-0.320	-0.096	1.000							
7	ln Mkt Cap	-0.029	0.556	0.278	0.172	0.124	-0.508	1.000						
8	ln ISSUESIZE	-0.262	0.122	0.029	-0.056	0.013	-0.023	-0.005	1.000					
9	Composite ESG Score	-0.042	-0.094	-0.328	-0.219	0.227	0.056	-0.071	0.180	1.000				
10	Weighted E Pillar	0.231	-0.536	-0.499	-0.112	-0.158	0.346	-0.435	-0.085	0.551	1.000			
11	Weighted S Pillar	-0.258	0.369	0.353	-0.076	0.422	-0.156	0.357	0.209	0.183	-0.667	1.000		
12	Weighted G Pillar	-0.284	0.729	0.192	0.055	0.102	-0.624	0.495	0.203	-0.066	-0.674	0.470	1.000	
13	ln Lead Spread	0.574	-0.701	-0.384	-0.359	-0.104	0.507	-0.485	-0.102	0.077	0.415	-0.316	-0.500	1.000

Notes: This table presents the correlation matrices for brown and green samples. Panel A presents correlation matrices of variables for the brown sample. Panel B presents correlation matrices of variables for the green sample.

Table 5: Impact of ESG on bond spreads: Full sample

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
ESG	-0.028	-0.075***	-0.058**	-0.044**	-0.033	-0.028	-0.022	-0.012	0.002	0.018
	(0.017)	(0.021)	(0.026)	(0.021)	(0.020)	(0.021)	(0.019)	(0.016)	(0.012)	(0.015)
ROA	-0.015***	-0.017***	-0.017***	-0.016***	-0.015***	-0.015***	-0.015***	-0.014***	-0.014***	-0.013***
	(0.002)	(0.003)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)
ICR	0.005***	0.004**	0.005***	0.005***	0.005***	0.005***	0.006***	0.006***	0.006***	0.006***
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)
GROWTH	0.0001	0.001***	0.001***	0.0004	0.0002	0.0001	-0.0001	-0.0003	-0.0006**	-0.001***
	(0.0003)	(0.0004)	(0.0003)	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0003)	(0.0003)
LEV	0.005***	0.004**	0.004***	0.005***	0.005***	0.005***	0.005***	0.006***	0.006***	0.006***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
ln(MKTCAP)	-0.089***	-0.088***	-0.088***	-0.089***	-0.089***	-0.089***	-0.090***	-0.090***	-0.091***	-0.091***
	(0.009)	(0.013)	(0.012)	(0.009)	(0.007)	(0.009)	(0.008)	(0.009)	(0.012)	(0.008)
Constant	5.782***									
	(0.138)									
t2	0.499***	0.439***	0.461***	0.479***	0.492***	0.499***	0.506***	0.519***	0.537***	0.558***
	(0.016)	(0.015)	(0.016)	(0.021)	(0.016)	(0.014)	(0.019)	(0.016)	(0.016)	(0.021)
t3	0.110***	0.244***	0.195***	0.155***	0.126***	0.110***	0.093***	0.064***	0.022	-0.024
	(0.017)	(0.012)	(0.025)	(0.023)	(0.014)	(0.014)	(0.016)	(0.019)	(0.016)	(0.019)
t4	0.116***	0.170***	0.150***	0.134***	0.122***	0.116***	0.109***	0.098***	0.081***	0.062***
	(0.024)	(0.028)	(0.030)	(0.025)	(0.025)	(0.018)	(0.025)	(0.023)	(0.029)	(0.023)
t5	0.149***	0.211***	0.189***	0.170***	0.157***	0.149***	0.142***	0.128***	0.109***	0.088***
	(0.024)	(0.032)	(0.035)	(0.026)	(0.019)	(0.023)	(0.022)	(0.021)	(0.024)	(0.027)
t6	0.224***	0.284***	0.262***	0.244***	0.231***	0.224***	0.217***	0.204***	0.185***	0.165***
	(0.029)	(0.039)	(0.029)	(0.026)	(0.028)	(0.028)	(0.024)	(0.024)	(0.027)	(0.028)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Bloomberg (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 487 US corporate bonds from year 2017 to 2022. All the variables are described in Table 1. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

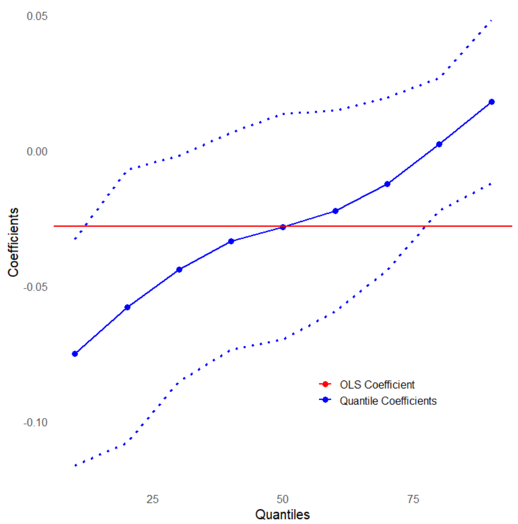

Figure 1: ESG Score coefficients across quantiles for full sample

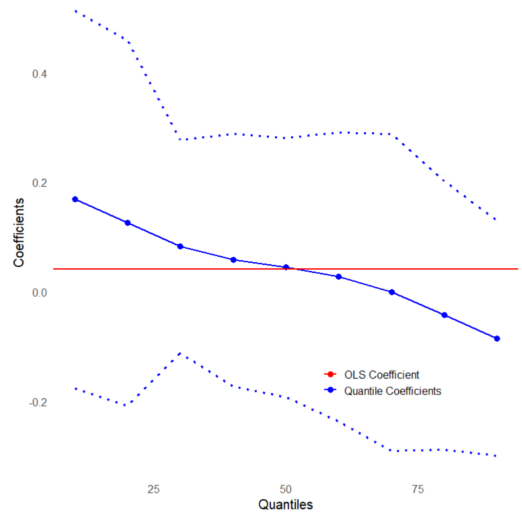

Figure 2: E Score coefficients across quantiles for full sample

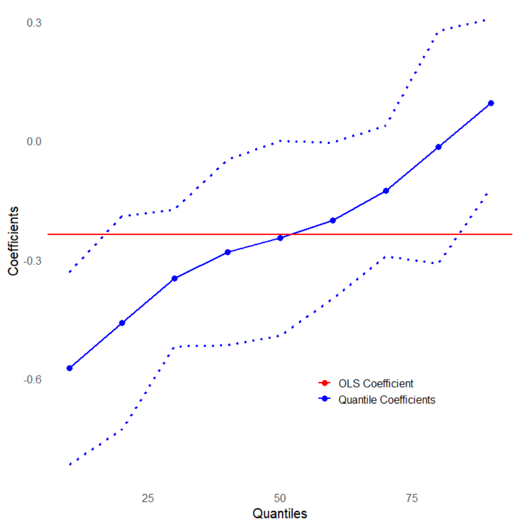

Figure 3: S Score coefficients across quantiles for full sample

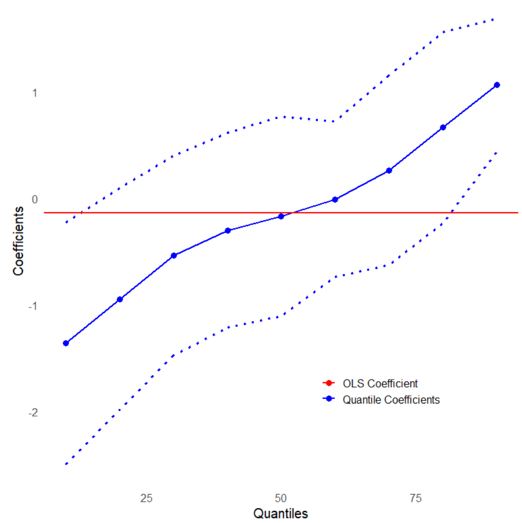

Figure 4: G Score coefficients across quantiles for full sample

Table 6 presents the impact of the individual weighted pillars (E, S, and G) of ESG on bond spreads for the full sample. Column (1) reveals that the weighted S pillar is the only significant pillar in influencing the bond spread. This result is similar to the findings of Li and Adriaens (2024), who also find that only S pillar bears an impact on bond spreads when a mix of companies from different industries are analysed. The results in Table 6 indicate that a one-point increase in the weighted S pillar will lead to a 0.237 decrease in the average bond spread. The effect of weighted E and G pillars is insignificant. However, the panel quantile regression results show that the impact of the weighted G pillar is significant only at the tails (extreme quantiles) of the bond spread distribution. The effect is only signficant at the 10th, 20th and the 90th quantiles. Interestingly, at the 10th and the 20th quantile the effect of the weighted G pillar on the bond spreads is negative while it is positive at the 90the quantile. This implies that the investors reward improvements in the weighted G pillar, by accepting lower returns on bonds, only at lower values of spread. At higher values of spread, investors penalize improvements in weighted G pillar by demanding higher returns on bonds, thereby leading to higher spreads. Panel quantile regression results also show that the effect of weighted S pillar on bond spreads is negative and significant only for values of bond spread below 70th percentile. The effect becomes smaller with each successive quantile.

Table 7 presents the impact of composite ESG on bond spreads for the brown sample. From column (1), it is evident that the impact of ESG on is negative and stronger than observed for the full sample (in Table 5). The panel quantile regression results indicate that the impact of ESG on bond spread is increasing in quantiles i.e. the impact becomes stronger at higher quantiles. This monotonicity in the coefficient of ESG implies that the impact of ESG on bond spreads is larger(smaller) for higher(lower) values of bond spreads. This result is in line with quite a few studies conducted in this area (Lian et al., 2023; Li et al., 2024). This shows that investors accept lower(higher) return on their bonds when ESG ratings are high(low) in case of brown/heavily emitting companies and, this relationship is more robust in case of bond with higher spreads.

Table 6: Impact of weighted E, S, and G pillars on bond spreads: Full sample

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
Weighted E pillar	0.041	0.169	0.126	0.083	0.058	0.045	0.028	-0.001	-0.043	-0.085
	(0.122)	(0.176)	(0.170)	(0.099)	(0.118)	(0.121)	(0.134)	(0.148)	(0.125)	(0.109)
Weighted S pillar	-0.237**	-0.574***	-0.460***	-0.347***	-0.282**	-0.246**	-0.201**	-0.126	-0.016	0.095
	(0.112)	(0.124)	(0.137)	(0.088)	(0.119)	(0.125)	(0.100)	(0.084)	(0.150)	(0.109)
Weighted G pillar	-0.136	-1.356**	-0.942*	-0.534	-0.298	-0.168	-0.006	0.266	0.665	1.066***
	(0.423)	(0.579)	(0.531)	(0.478)	(0.466)	(0.477)	(0.373)	(0.454)	(0.456)	(0.318)
ROA	-0.015***	-0.018***	-0.017***	-0.016***	-0.015***	-0.015***	-0.015***	-0.014***	-0.014***	-0.013***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.002)	(0.003)
ICR	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
GROWTH	0.0001	0.001***	0.001	0.0003**	0.0002	0.0001	-0.00002	-0.0002	-0.0005	-0.001*
	(0.0003)	(0.0003)	(0.0004)	(0.0002)	(0.0003)	(0.0003)	(0.0003)	(0.0004)	(0.0003)	(0.0004)
LEV	0.006***	0.006***	0.006***	0.006***	0.006***	0.006***	0.006***	0.006***	0.006***	0.006***
	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
ln(MKTCAP)	-0.085***	-0.068***	-0.074***	-0.080***	-0.083***	-0.085***	-0.087***	-0.091***	-0.096***	-0.102***
	(0.011)	(0.015)	(0.007)	(0.011)	(0.010)	(0.011)	(0.012)	(0.013)	(0.009)	(0.011)
Constant	5.849***									
	(0.360)									
t2	0.498***	0.435***	0.456***	0.477***	0.490***	0.496***	0.505***	0.519***	0.539***	0.560***
	(0.016)	(0.016)	(0.020)	(0.017)	(0.013)	(0.016)	(0.017)	(0.020)	(0.019)	(0.028)
t3	0.102***	0.218***	0.179***	0.140***	0.118***	0.105***	0.090***	0.064***	0.026***	-0.012
	(0.018)	(0.028)	(0.019)	(0.023)	(0.013)	(0.018)	(0.021)	(0.021)	(0.016)	(0.018)
t4	0.109***	0.129***	0.122***	0.115***	0.111***	0.109***	0.106***	0.102***	0.095***	0.088***
	(0.025)	(0.027)	(0.030)	(0.025)	(0.023)	(0.025)	(0.031)	(0.021)	(0.019)	(0.027)
t5	0.141***	0.181***	0.167***	0.154***	0.146***	0.142***	0.137***	0.128***	0.115***	0.102***
	(0.025)	(0.024)	(0.032)	(0.029)	(0.021)	(0.025)	(0.020)	(0.028)	(0.024)	(0.025)
t6	0.212***	0.242***	0.232***	0.222***	0.216***	0.213***	0.209***	0.202***	0.192***	0.183***
	(0.030)	(0.031)	(0.043)	(0.028)	(0.031)	(0.027)	(0.024)	(0.034)	(0.025)	(0.034)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 2 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are weighted E, S, and G pillar provided by Bloomberg, Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 487 US corporate bonds from year 2017 to 2022. All the variables are described in Table 1. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

Table 7: Impact of composite ESG ratings on bond spreads: Brown sample

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
ESG	-0.115**	-0.045	-0.083**	-0.098*	-0.105**	-0.115**	-0.123***	-0.139***	-0.149***	-0.176***
	(0.048)	(0.067)	(0.042)	(0.054)	(0.049)	(0.052)	(0.040)	(0.041)	(0.045)	(0.044)
ROA	-0.0001	-0.0004	-0.0002	-0.0002	-0.0001	-0.0001	-0.00002	0.0001	0.0001	0.0003
	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.005)	(0.002)	(0.003)
ICR	0.005**	0.008**	0.006**	0.006*	0.006*	0.005*	0.005	0.005*	0.004*	0.003
	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.004)
GROWTH	-0.0005	-0.0001	-0.0003***	-0.0004	-0.0004	-0.0005	-0.001	-0.001**	-0.001	-0.001*
	(0.0004)	(0.001)	(0.001)	(0.0005)	(0.0004)	(0.001)	(0.0004)	(0.0003)	(0.001)	(0.0005)
LEV	0.009**	0.015***	0.012***	0.011***	0.010***	0.009**	0.009***	0.007	0.006*	0.004
	(0.004)	(0.005)	(0.004)	(0.004)	(0.003)	(0.004)	(0.003)	(0.005)	(0.003)	(0.003)
ln(MKTCAP)	-0.336***	-0.130	-0.242***	-0.287***	-0.308***	-0.338***	-0.361***	-0.408***	-0.440***	-0.520***
	(0.090)	(0.118)	(0.089)	(0.086)	(0.102)	(0.095)	(0.109)	(0.115)	(0.112)	(0.091)
Constant	8.538***									
	(1.070)									
t2	0.307***	0.546***	0.416***	0.364***	0.339***	0.305***	0.279***	0.224***	0.187***	0.094**
	(0.037)	(0.056)	(0.043)	(0.044)	(0.046)	(0.040)	(0.039)	(0.029)	(0.022)	(0.039)
t3	0.243***	0.346***	0.290***	0.268***	0.257***	0.242***	0.231***	0.207***	0.191***	0.151***
	(0.054)	(0.084)	(0.066)	(0.051)	(0.060)	(0.051)	(0.044)	(0.058)	(0.040)	(0.059)
t4	0.285***	0.305***	0.294***	0.290***	0.288***	0.285***	0.283***	0.278***	0.275***	0.267***
	(0.074)	(0.095)	(0.072)	(0.076)	(0.074)	(0.082)	(0.071)	(0.074)	(0.052)	(0.066)
t5	0.256***	0.206***	0.233***	0.244***	0.249***	0.257***	0.262***	0.274***	0.282***	0.301***
	(0.080)	(0.080)	(0.079)	(0.070)	(0.094)	(0.081)	(0.079)	(0.083)	(0.083)	(0.096)
t6	0.316***	0.363***	0.337***	0.327***	0.322***	0.315***	0.310***	0.299***	0.292***	0.274***
	(0.077)	(0.089)	(0.079)	(0.066)	(0.076)	(0.079)	(0.057)	(0.063)	(0.078)	(0.057)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Bloomberg (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 61 US corporate bonds from year 2017 to 2022. All the variables are described in Table 3. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

Table 8 presents the impact of the individual weighted pillars (E, S, and G) of ESG on bond spreads. From column (1), it can be observed that weighted E pillar is significant and negative. While weighted S and weighted G pillars are insignificant. This result implies that a one-point increase in the weighted E pillar leads to a 0.579 point decrease in the average bond spread. This result is in line with the findings in the literature that the E pillar has a negative relationship with the cost of debt (Apergis et al., 2022). However, it is important to note that the effect of E pillar on bond spread is not even across all quantiles. The panel quantile regression results reveal that the weighted E pillar has a significant and stronger (more negative) impact on the bond spreads at higher quantiles (50th to 90th). This result indicates that the weighted E pillar becomes an important determinant of corporate bond spread at higher spreads. This finding implies that while the impact of weighted E pillar is insignificant at lower quantiles of bond spreads, for more risky bonds (bonds corresponding to higher spreads), this impact is significant and more profound. Panel qunatile regression results also indicate that weighted G pillar has a positive and significant impact on bond spreads at lower quantiles (10th to 40th). This result suggests that an improvement in weighted G pillar causes the average bond spread to increase - investors demand higher returns on their bonds when weighted G pillar rating improves. This result is not unique as Jang et al. (2020) find that improvement in G score leads to increase in bond returns. They highlight that this result is plausible as any efforts to improve corporate governance undertaken by the management are viewed negatively by the bond holders, these efforts primarily benefit the equity holders (Klock et al., 2005). This result is also observed in Table 6 for the right-hand extreme quantile of the full sample.

Table 8: Impact of E, S, and G on bond spreads: Brown sample

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
Weighted E pillar	-0.579**	0.109	-0.216	-0.424	-0.490	-0.627***	-0.681**	-0.792***	-0.995***	-1.222***
	(0.275)	(0.557)	(0.350)	(0.304)	(0.353)	(0.207)	(0.269)	(0.280)	(0.224)	(0.189)
Weighted S pillar	-0.317	-0.151	-0.229	-0.279	-0.295	-0.328	-0.341	-0.368	-0.417	-0.472
	(0.334)	(0.391)	(0.353)	(0.334)	(0.356)	(0.400)	(0.345)	(0.365)	(0.439)	(0.470)
Weighted G pillar	1.502	4.130**	2.891**	2.094	1.841*	1.320	1.111	0.688	-0.086	-0.954
	(1.056)	(1.859)	(1.344)	(1.380)	(1.024)	(1.124)	(1.026)	(1.117)	(0.807)	(0.831)
ROA	-0.00001	0.001	0.0005	0.0002	0.0001	-0.0001	-0.0001	-0.0003	-0.001	-0.001
	(0.003)	(0.005)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.004)	(0.005)	(0.002)
ICR	0.006**	0.007	0.007**	0.006**	0.006**	0.006*	0.006**	0.005*	0.005*	0.004*
	(0.002)	(0.006)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.002)
GROWTH	-0.001	-0.0001	-0.0003	-0.0004	-0.0005	-0.001	-0.001	-0.001	-0.001**	-0.001
	(0.0004)	(0.001)	(0.001)	(0.001)	(0.0004)	(0.0004)	(0.001)	(0.0004)	(0.0003)	(0.001)
LEV	0.009**	0.018***	0.014***	0.011**	0.010***	0.008***	0.008*	0.006**	0.003	0.0004
	(0.004)	(0.007)	(0.005)	(0.004)	(0.004)	(0.003)	(0.004)	(0.004)	(0.005)	(0.004)
ln(MKTCAP)	-0.371***	-0.197**	-0.279***	-0.332***	-0.348***	-0.383***	-0.397***	-0.425***	-0.476***	-0.533***
	(0.089)	(0.097)	(0.095)	(0.084)	(0.080)	(0.106)	(0.092)	(0.115)	(0.122)	(0.121)
Constant	7.852***									
	(1.455)									
t2	0.296***	0.503***	0.406***	0.343***	0.323***	0.281***	0.265***	0.232***	0.170***	0.102***
	(0.039)	(0.059)	(0.044)	(0.045)	(0.044)	(0.046)	(0.043)	(0.039)	(0.029)	(0.030)
t3	0.245***	0.289***	0.268***	0.255***	0.250***	0.241***	0.238***	0.231***	0.217***	0.203***
	(0.055)	(0.075)	(0.069)	(0.061)	(0.055)	(0.052)	(0.054)	(0.057)	(0.062)	(0.043)
t4	0.284***	0.274**	0.278***	0.281***	0.282***	0.284***	0.285***	0.287***	0.290***	0.293***
	(0.075)	(0.121)	(0.090)	(0.070)	(0.079)	(0.071)	(0.080)	(0.079)	(0.074)	(0.051)
t5	0.250***	0.130	0.187**	0.223***	0.235***	0.259***	0.268***	0.288***	0.323***	0.363***
	(0.080)	(0.117)	(0.092)	(0.085)	(0.073)	(0.082)	(0.079)	(0.087)	(0.082)	(0.076)
t6	0.305***	0.254**	0.278***	0.294***	0.299***	0.309***	0.313***	0.321***	0.336***	0.353***
	(0.078)	(0.121)	(0.091)	(0.085)	(0.073)	(0.064)	(0.078)	(0.059)	(0.062)	(0.073)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 2 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are weighted E, S, and G pillar provided by Bloomberg, Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 61 US corporate bonds from year 2017 to 2022. All the variables are described in Table 3. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.

*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

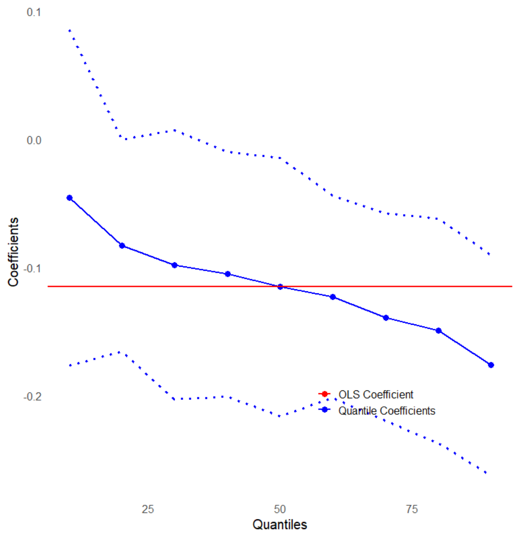

Figure 5: ESG Score coefficients across quantiles for brown sample

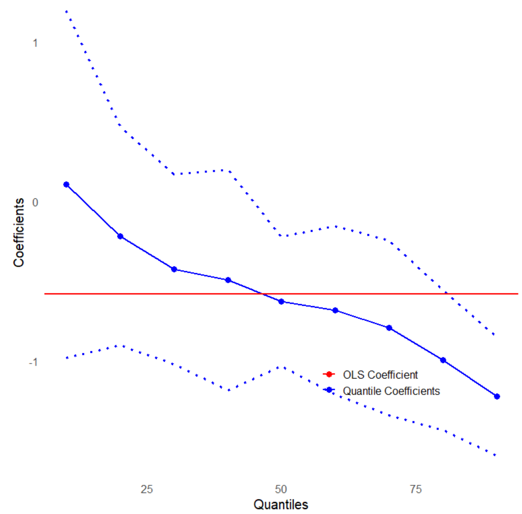

Figure 6: E Score coefficients across quantiles for brown sample

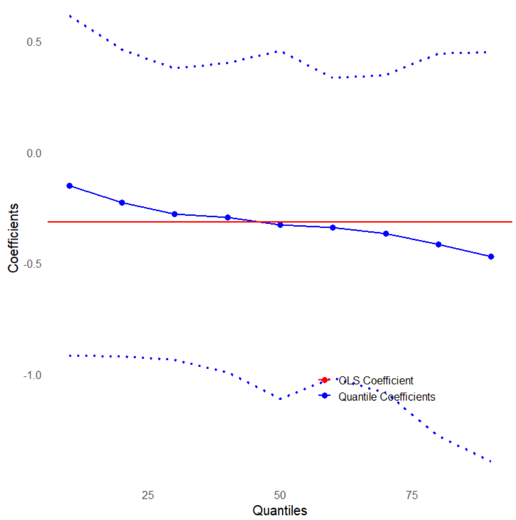

Figure 7: S Score coefficients across quantiles for brown sample

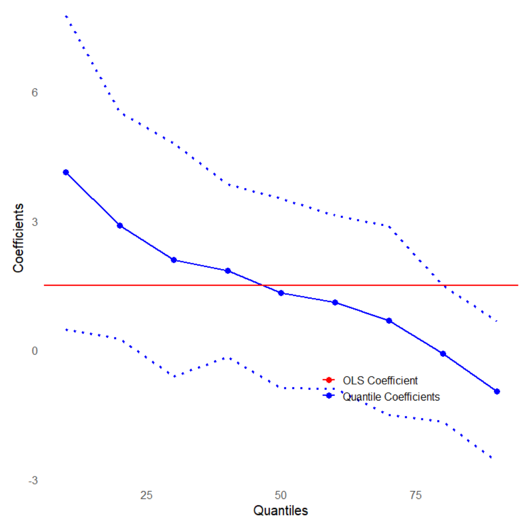

Figure 8: G Score coefficients across quantiles for brown sample

Table 9 presents the impact of ESG on bond spreads for the green sample. There is a clear contrast between the results presented in Table 7 for brown sample and results presented in Table 9 for green sample. Column (1) result indicates that the composite ESG score has a positive and significant impact on bond spreads. There is scant evidence pertaining to sectoral differences in the impact of ESG on bond spreads, However, some studies (Li and Adriaens, 2024; Halling et al., 2021) acknowledge that there could be heterogeneities in the relationship between ESG and bond spreads based on the industrial composition of the sample being studied. The results presented in Table 9 somewhat correspond to the results in Li and Adriaens (2024). Li and Adriaens (2024) find that the impact of ESG on bond spreads is positive for a sample comprising the consumer staples, consumer discretionary and the health care sectors. The sectors comprising the green sample employed here account for 45% of the entire sample. Palmieri et al. (2023) find that companies operating in brown sectors (energy, industrials, and materials) have a significant positive impact on the probability of default of companies. Whereas, companies operating in green sectors (such communications, technology, health, consumer staples, and consumer discretionary products) have no statistically significant impact on probability of default. They highlight that this result may stem from the fact that brown sectors are intrinsically more exposed to sustainability issues. This finding and the rationale behind it affirms that since green sectors are at a lower risk of default, investors deem green sectors as safe/low risk[5]. So, any efforts directed towards addressing ESG related issues are considered wasteful and therefore, penalized by investors. The coefficients of ESG across quantiles are monotonically increasing but do not increase steeply. This indicates that the quantile effect (caused by the location effect) is negligible and not as great as it is in case of the brown sample.

Table 10 presents the impact of E, S, and G on bond spreads for the green sample. Column (1) results indicate that all weighted individual pillars exert a positive impact of bond spreads. The weighted governance pillar affects the bond spreads the most followed by the weighted E pillar and the weighted S pillar. Columns (2) to (10) indicate that the effect of weighted E pillar is decreasing with quantiles. It highlights that bonds with lower spreads in the green sample are more strongly affected by the weighted E pillar compared to bonds with high spreads. This implies that firms with lower spreads (indicating firms having a very low credit risk) are penalized more for making efforts to address their environmental issues.

[5] It is is also evident from Table 3 that brown sample has a wider mean spread compared to the green sample which indicates that investors demand a higher return on brown companies' bonds compared to green companies' bonds.

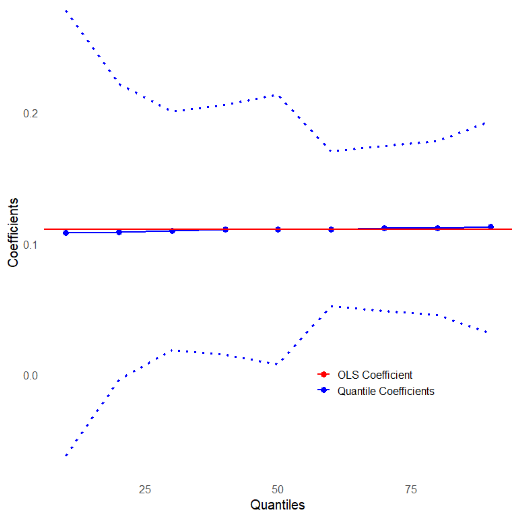

Figure 9: ESG Score coefficients across quantiles for green sample

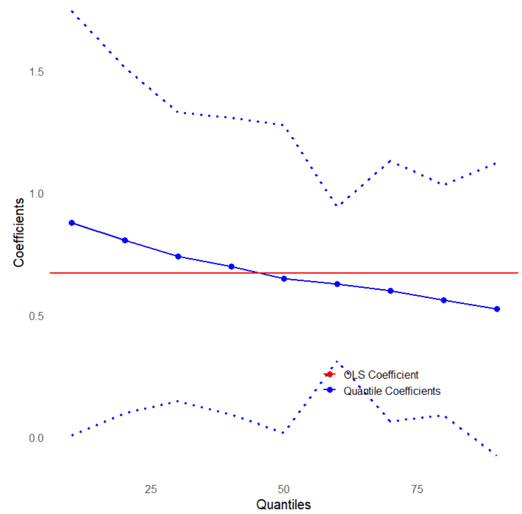

Figure 10: E Score coefficients across quantiles for green sample

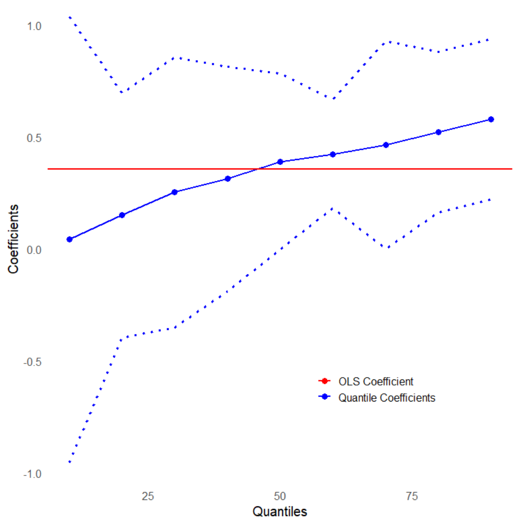

Figure 11: S Score coefficients across quantiles for green sample

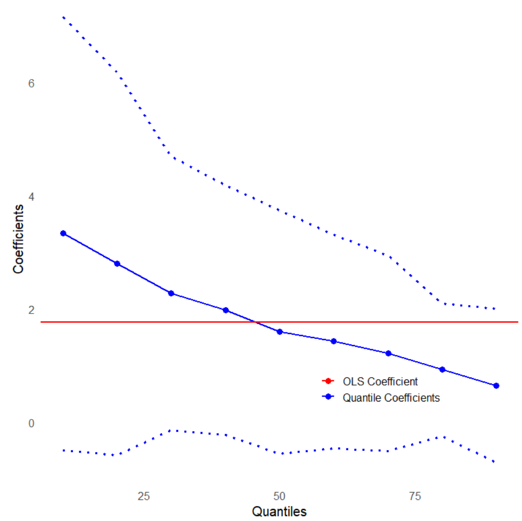

Figure 12: G Score coefficients across quantiles for green sample

This is in line with the rationale behind investors penalizing firms (in form of demanding higher returns) for making efforts to improve their ESG performance. A similar result is obtained for weighted G pillar - the coefficient of the weighted G pillar decreases with the quantiles. However, it is only significant for the 30th and 40th quantiles. Interestingly, the coefficient of weighted S pillar is higher at higher quantiles and significant only for quantiles above the 40th (50th quanilte onwards). This finding indicates that the impact of the weighted S pillar on bond spreads becomes tangible only for values of bond spread above the median (or equivalently for high values of bond spreads indicating relatively high risk bonds). Equivalently, high risk bonds bear higher penalty for improving their weighted S pillar.

Table 9: Impact of ESG on bond spreads: Green sample

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
ESG	0.111**	0.108	0.109*	0.110**	0.111**	0.111**	0.111***	0.112***	0.112***	0.113***
	(0.042)	(0.087)	(0.058)	(0.047)	(0.049)	(0.052)	(0.030)	(0.032)	(0.034)	(0.041)
ROA	-0.019***	-0.030***	-0.026***	-0.023***	-0.020***	-0.019***	-0.017***	-0.015***	-0.013***	-0.012***
	(0.003)	(0.009)	(0.007)	(0.004)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.004)
ICR	-0.0003	0.007	0.004	0.002	-0.00001	-0.001	-0.002	-0.003	-0.004	-0.006**
	(0.002)	(0.005)	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
GROWTH	-0.001*	-0.005***	-0.004**	-0.003*	-0.002**	-0.001	-0.001	0.000005	0.001	0.001
	(0.001)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.0005)	(0.001)
LEV	0.001***	0.011***	0.010***	0.009***	0.008**	0.007***	0.007***	0.006***	0.005**	0.005**
	(0.002)	(0.004)	(0.003)	(0.003)	(0.004)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ln(MKTCAP)	-0.044	0.038	0.008	-0.016	-0.041	-0.048	-0.062*	-0.074***	-0.089***	-0.104***
	(0.033)	(0.049)	(0.058)	(0.031)	(0.033)	(0.033)	(0.033)	(0.027)	(0.028)	(0.029)
Constant	4.569***									
t2	0.424***	0.457***	0.445***	0.436***	0.426***	0.423***	0.417***	0.412***	0.406***	0.400***
	(0.038)	(0.058)	(0.049)	(0.038)	(0.032)	(0.032)	(0.043)	(0.030)	(0.047)	(0.037)
t3	0.083**	0.246***	0.186***	0.139***	0.090*	0.075***	0.046	0.022	-0.007	-0.036
	(0.034)	(0.073)	(0.057)	(0.037)	(0.035)	(0.029)	(0.034)	(0.028)	(0.038)	(0.044)
t4	-0.039	0.028	0.003	-0.016	-0.036	-0.042	-0.054	-0.064*	-0.076	-0.088
	(0.048)	(0.089)	(0.059)	(0.051)	(0.049)	(0.044)	(0.046)	(0.036)	(0.058)	(0.063)
t5	0.021	0.183*	0.123*	0.077	0.027	0.013	-0.015	-0.040	-0.068*	-0.098**
	(0.049)	(0.101)	(0.066)	(0.053)	(0.051)	(0.052)	(0.050)	(0.039)	(0.037)	(0.049)
t6	-0.033	-0.063	-0.052	-0.044	-0.034	-0.032	-0.026	-0.022	-0.017	-0.011
	(0.064)	(0.120)	(0.097)	(0.079)	(0.071)	(0.067)	(0.049)	(0.041)	(0.042)	(0.049)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Bloomberg (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 66 US corporate bonds from year 2017 to 2022. All the variables are described in Table 3. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

Table 10: Impact of E, S, and G on bond spreads: Green sample

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
Weighted E pillar	0.671**	0.877**	0.806**	0.739**	0.699**	0.649**	0.627***	0.599**	0.561**	0.525*
	(0.271)	(0.444)	(0.361)	(0.302)	(0.310)	(0.321)	(0.161)	(0.272)	(0.240)	(0.306)
Weighted S pillar	0.356*	0.043	0.151	0.254	0.313	0.391*	0.423***	0.466**	0.523***	0.579***
	(0.206)	(0.508)	(0.279)	(0.308)	(0.256)	(0.201)	(0.124)	(0.237)	(0.183)	(0.183)
Weighted G pillar	1.770*	3.336	2.799	2.283*	1.984*	1.597	1.432	1.219	0.931	0.652
	(1.036)	(1.952)	(1.723)	(1.232)	(1.124)	(1.098)	(0.961)	(0.879)	(0.599)	(0.690)
ROA	-0.017***	-0.025***	-0.023***	-0.020***	-0.019***	-0.017***	-0.016***	-0.015***	-0.013***	-0.012***
	(0.004)	(0.006)	(0.004)	(0.005)	(0.004)	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)
ICR	-0.003	0.001	0.00002	-0.001	-0.002	-0.003	-0.004	-0.004	-0.005**	-0.006
	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.003)	(0.002)	(0.004)
GROWTH	-0.001	-0.004***	-0.003**	-0.002***	-0.002*	-0.001	-0.0005	-0.00002	0.001	0.001*
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LEV	0.006***	0.009**	0.008***	0.007***	0.007**	0.006***	0.006***	0.005**	0.005****	0.004**
	(0.002)	(0.004)	(0.003)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ln(MKTCAP)	-0.056*	0.024	-0.003	-0.030	-0.045	-0.065*	-0.074**	-0.085***	-0.099**	-0.114***
	(0.033)	(0.049)	(0.055)	(0.047)	(0.034)	(0.039)	(0.031)	(0.029)	(0.040)	(0.041)
Constant	2.966***									
	(0.969)									
t2	0.424***	0.484***	0.463***	0.444***	0.432***	0.418***	0.411***	0.403***	0.392***	0.382***
	(0.038)	(0.049)	(0.038)	(0.041)	(0.026)	(0.034)	(0.038)	(0.033)	(0.017)	(0.047)
t3	0.083**	0.240***	0.186***	0.134***	0.105***	0.066	0.049*	0.028	-0.001	-0.029
	(0.034)	(0.053)	(0.050)	(0.044)	(0.035)	(0.041)	(0.027)	(0.039)	(0.035)	(0.049)
t4	-0.028	0.093	0.051	0.012	-0.012	-0.041	-0.054	-0.071	-0.093	-0.114
	(0.053)	(0.076)	(0.070)	(0.065)	(0.050)	(0.049)	(0.045)	(0.053)	(0.057)	(0.070)
t5	0.041	0.242**	0.173**	0.106	0.068	0.018	-0.003	-0.030	-0.067	-0.103**
	(0.054)	(0.098)	(0.069)	(0.080)	(0.058)	(0.069)	(0.039)	(0.054)	(0.045)	(0.047)
t6	-0.022	-0.036	-0.031	-0.027	-0.024	-0.021	-0.019	-0.018	-0.015	-0.013
	(0.067)	(0.119)	(0.105)	(0.080)	(0.070)	(0.064)	(0.035)	(0.061)	(0.052)	(0.058)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 2 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are weighted E, S, and G pillar provided by Bloomberg, Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 66 US corporate bonds from year 2017 to 2022. All the variables are described in Table 3. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

6 Robustness Checks

6.1 Robustness check - I: Using an alternate classification criterion

In this section, the results using an alternate classification of green and brown are presented. This classification is broader but it shares many similar features with the classification based on emission intensity. In this classification, the full sample is divided into brown and green based on the weight assigned to the E and S pillars of the composite ESG score (Classification-2). The pillar weights indicate the materiality/relevance of each pillar to the company. For example, Bloomberg assigns a high E pillar weight of 45.45% to Apache Corp (an Oil & Gas prodcution and exploration company). This is because it a member company of a sector that has a very high impact on the physical environment through its operations. So, the ESG issues that are most relevant to the company's materiality are those related to the environmental pillar or the 'E' of the ESG score. Therefore, companies that are heavily weighted on E are also typically those that have the highest environmental impact. These companies are classified as brown. On the other hand, a company such as Pfizer Inc has a heavy weight of 55.56% on the social pillar or 'S' of the ESG score and only a small weight of 11.11% on the E pillar. This is because Pfizer Inc is a biotechnology and pharamaceutical company and for a pharma company its social impact (that is captured by the S pillar) is the most important. The S pillar considers topics like inequality, working conditions, human rights, product safety, etc. Since product safety is the most consequential issue for a pharma company, the S pillar has the highest weight attached to it. Companies having a high weight on S, automaically have a low weight on E implying that these companies are relatively less environmentally sensitive or greener. Therefore, we use pillar weights as the classification criteria to verify if the results observed for brown and green samples still hold. Companies having a pillar weight of 40% or higher on E are classified as brown. And, companies having a pillar weight of 40% or higher on S are classified as green. These companies are termed green as they have a much smaller mean E weight of 22.48 as opposed to 44.63 for brown sample (refer to Table 11) implying that environmental issues are in general not a matter of great concern for such companies. This is also the case for classification 1, where the mean E weight for the brown sample is 45.18% while it is 28.45% for the green sample and the mean S weight for the brown sample is 26.07% and 40.75% for the green sample. The summary statistics and the sectoral distribution of bonds for the above classification are reported in Table 11.

Apart from the similarity in average pillar weights across the two classification criteria, the evolution of the average composite ESG scores over time is also similar (see Figure 13 and 14). The average ESG score curve for brown sample is above the green samples' ESG score curve for both classifications.

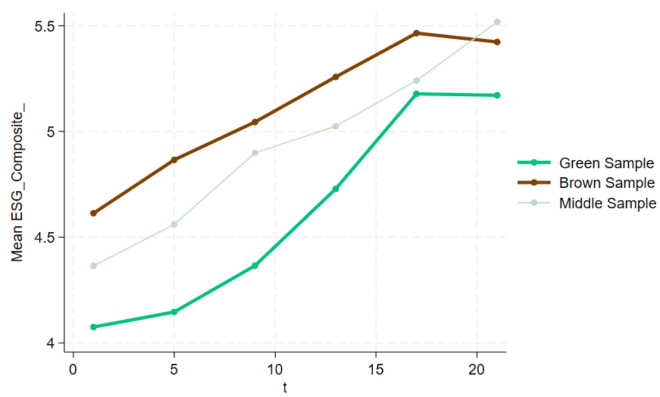

Figure 13: ESG Score across time for brown, green, and unclassified(middle) sample: classifcation-1

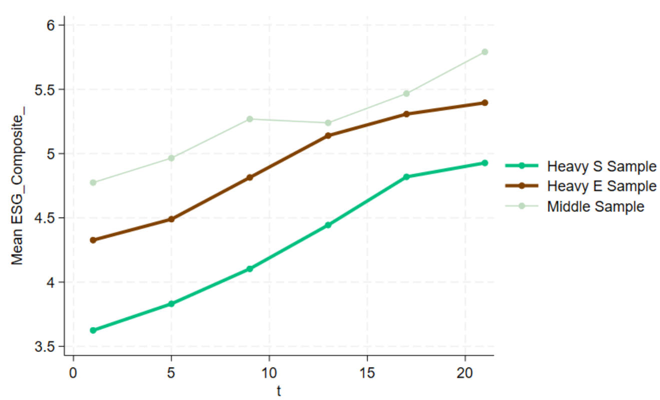

Figure 14: ESG Score across time for brown, green, and unclassified(middle) sample: classifcation-2

The average ln lead bond spreads' curves, the individual weighted pillar scores are also similar for sub-samples created in both classifications.

Table 11: Summary statistics: Brown and Green sub-samples (based on classification-2)

Panel A: Descriptive Statistics

Classification-2: based on pillar weights										
	Heavy E weight (sample with bonds above 40% weight assigned to pillar E)					Heavy S weight (sample with bonds above 40% weight assigned to pillar S)				
Variable	Obs	Mean	Std. dev.	Min	Max	Obs	Mean	Std. dev.	Min	Max
Weighted E Pillar	882	1.010	0.150	0.533	1.293	720	0.513	0.197	0.176	0.836
Weighted S Pillar	882	0.595	0.134	0.192	0.894	720	0.908	0.196	0.558	1.418
Weighted G Pillar	882	0.817	0.118	0.566	1.153	720	0.871	0.099	0.530	1.028
Composite ESG Score	882	4.912	0.949	2.090	6.980	720	4.292	0.896	1.580	7.470
ln Lead Spread	882	5.052	0.463	2.992	6.533	720	4.922	0.656	1.751	7.628
Maturity (in years)	882	28.061	7.470	5.000	50.000	720	27.842	7.721	10.000	50.000
Rating	882	11.354	1.750	6.000	14.000	720	11.550	2.968	3.000	19.000
ROA	882	5.156	6.588	-30.946	29.718	720	4.833	6.090	-18.001	27.353
ICR	882	5.678	7.217	-32.443	74.169	720	6.525	11.601	-34.583	59.781
Growth	882	7.395	21.765	-62.866	233.828	720	4.115	20.020	-50.058	104.899
LEV	882	39.414	11.542	14.401	77.724	720	36.373	10.570	9.894	68.877
ln ISSUESIZE	882	19.380	1.494	14.745	22.292	720	20.190	0.855	18.084	21.976
ln Mkt Cap	882	10.419	0.928	7.351	12.460	720	11.277	1.349	6.414	14.874
E WEIGHT	882	44.634	2.601	40.000	50.000	720	22.482	7.908	11.110	33.330
S WEIGHT	882	26.969	5.492	12.500	33.330	720	47.385	5.865	40.000	55.560
G WEIGHT	882	28.391	3.536	25.000	37.500	720	30.129	2.758	25.000	33.330

Panel B: Sectoral Distribution

Brown Sample			Green Sample		
	Frequency	%		Frequency	%
Sector			Sector		
Consumer Discretionary	108	12%	Communications	222	31%
Consumer Staples	96	11%	Consumer Discretionary	42	6%
Industrials	168	19%	Healthcare	216	30%
Materials	144	16%	Industrials	132	18%
Oil&Gas	144	16%	Technology	108	15%
Real Estate	30	3%	Total	720	100%
Technology	18	2%			
Utilities	174	20%			
Total	882	100%			

Tables 12 and 13 present the results of sub-samples (brown and green) created based on classification 2. It can be observed from the summary statistics reported in Table 11 that the total number of observations in the brown sample is 882 and in the green sample is 720 which is much greater compared to classification 1 (3). This implies that the sub-samples in Classification 2 are much broader compared to classification 1. As a result, the brown sub-sample (in classification 2) can be expected to include firms that are less brown while the green sub-sample (in classification 2) can be expected to include firms that are less green. Following this, it is plausible that the results obtained using this alternate classification are broadly similar but not the same.

From Table 12, the impact of ESG on bond spreads for brown sample (sample with heavy E) has been presented. It can be observed that the coefficient of ESG is negative and significant in column (1) presenting OLS results as well as in columns (2) to (10) presenting the panel quantile regression results. This shows that improvements in the ESG score result in a decrease in credit risk associated with bonds belonging to brown industries. This result is strong(significant) across the distribution of bond spreads.

Table 13 presents the impact of ESG on bond spreads for the green sample (sample with heavy S). The coefficient of ESG is positive and significant in column (1) presenting the OLS results and in columns (2) through (10) presenting the results of panel quantile regression. This implies that improvements in the ESG score result in an increase in the credit risk associated with the bonds belonging to the green industries.

Table 12: Impact of ESG on bond spreads: Brown sample (Heavy E)

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
ESG	-0.073***	-0.086***	-0.081***	-0.077***	-0.074***	-0.073***	-0.072***	-0.069***	-0.065***	-0.062**
	0.022	0.031	0.019	0.019	0.022	0.024	0.027	0.022	0.024	0.027
ROA	0.0003	0.002	0.001	0.001	0.0005	0.0003	0.0001	-0.0002	-0.001	-0.001
	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.003
ICR	0.0001	0.002	0.001	0.001	0.0003	0.0001	-0.0001	-0.0005	-0.001	-0.001
	0.002	0.002	0.003	0.002	0.002	0.002	0.002	0.002	0.002	0.002
GROWTH	-0.001	-0.001	-0.001*	-0.001*	-0.001***	-0.001***	-0.001**	-0.001**	-0.001**	-0.001
	0.0004	0.001	0.0004	0.0004	0.0003	0.0003	0.0004	0.0004	0.0004	0.001
LEV	0.007**	0.006**	0.006***	0.007***	0.007***	0.007***	0.007***	0.007**	0.007*	0.007**
	0.003	0.003	0.002	0.002	0.002	0.002	0.003	0.003	0.004	0.003
ln(MKTCAP)	-0.279***	-0.348***	-0.320***	-0.298***	-0.285***	-0.277***	-0.269***	-0.255***	-0.236***	-0.216***
	0.044	0.052	0.060	0.048	0.037	0.046	0.033	0.048	0.042	0.046
Constant	7.865									
	0.492									
t2	0.301***	0.400***	0.360***	0.328***	0.309***	0.298***	0.288***	0.268***	0.240***	0.212***
	0.021	0.030	0.026	0.024	0.025	0.016	0.019	0.024	0.019	0.024
t3	0.186***	0.328***	0.271***	0.224***	0.198***	0.182***	0.167***	0.138***	0.098***	0.057
	0.027	0.038	0.030	0.034	0.028	0.025	0.032	0.036	0.032	0.035
t4	0.205***	0.245***	0.229***	0.216***	0.209***	0.204***	0.200***	0.192***	0.181***	0.170***
	0.040	0.049	0.036	0.043	0.044	0.032	0.044	0.050	0.045	0.044
t5	0.200***	0.270***	0.242***	0.219***	0.206***	0.198***	0.190***	0.176***	0.157***	0.137***
	0.041	0.053	0.041	0.048	0.041	0.042	0.040	0.052	0.047	0.044
t6	0.250***	0.354***	0.312***	0.278***	0.259***	0.247***	0.236***	0.215***	0.186***	0.156***
	0.039	0.045	0.042	0.041	0.034	0.037	0.037	0.049	0.049	0.049
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Bloomberg (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 147 US corporate bonds from year 2017 to 2022. All the variables are described in Table 11. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

Table 13: Impact of ESG on bond spreads: Green sample (Heavy S)

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
ESG	0.054*	0.072*	0.066	0.061***	0.055**	0.054*	0.051***	0.047	0.041*	0.033
	(0.028)	(0.038)	(0.043)	(0.022)	(0.026)	(0.031)	(0.019)	(0.029)	(0.024)	(0.030)
ROA	-0.010***	-0.012***	-0.011***	-0.011***	-0.010***	-0.010***	-0.010***	-0.010**	-0.009**	-0.008**
	(0.003)	(0.004)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.004)
ICR	0.002	-0.0001	0.001	0.001	0.002	0.002	0.003	0.003	0.004	0.005**
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
GROWTH	0.0001	0.001	0.0004	0.0003	0.0001	0.0001	0.00003	-0.0001	-0.0002	-0.0004
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LEV	0.008***	0.011***	0.010***	0.009***	0.008**	0.008***	0.008***	0.007***	0.007**	0.006***
	(0.003)	(0.004)	(0.002)	(0.003)	(0.004)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
ln(MKTCAP)	-0.160**	-0.039	-0.080	-0.115*	-0.150**	-0.159***	-0.176***	-0.200***	-0.243***	-0.292***
	(0.062)	(0.078)	(0.067)	(0.065)	(0.073)	(0.050)	(0.057)	(0.066)	(0.062)	(0.062)
Constant	6.220***									
	(0.767)									
t2	0.284***	0.286***	0.285***	0.284***	0.284***	0.284***	0.283***	0.283***	0.282***	0.281***
	(0.021)	(0.034)	(0.025)	(0.023)	(0.022)	(0.023)	(0.022)	(0.028)	(0.033)	(0.033)
t3	-0.007	0.002	-0.001	-0.004	-0.007	-0.007	-0.009	-0.010	-0.013	-0.017
	(0.028)	(0.054)	(0.035)	(0.039)	(0.035)	(0.028)	(0.027)	(0.031)	(0.032)	(0.030)
t4	-0.127***	-0.186***	-0.166***	-0.149***	-0.132***	-0.128***	-0.119***	-0.108**	-0.087**	-0.063*
	(0.040)	(0.056)	(0.045)	(0.049)	(0.042)	(0.035)	(0.035)	(0.047)	(0.043)	(0.032)
t5	-0.044	-0.103	-0.083	-0.066	-0.049	-0.044	-0.036	-0.024	-0.003	0.021
	(0.050)	(0.067)	(0.056)	(0.051)	(0.054)	(0.048)	(0.053)	(0.051)	(0.040)	(0.042)
t6	-0.062	-0.315**	-0.228**	-0.157**	-0.082	-0.063	-0.027	0.023	0.113***	0.216***
	(0.065)	(0.126)	(0.108)	(0.068)	(0.073)	(0.074)	(0.058)	(0.062)	(0.044)	(0.051)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Bloomberg (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 120 US corporate bonds from year 2017 to 2022. All the variables are described in Table 11. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

6.2 Robustness check - II: Using an alternate measure of ESG

This section presents the results for model 1 alongside the results for panel quantile fixed effects regression as described in section 4.2 for a different measure of ESG - the Refinitiv ESG scores. The scoring methodology varies across all ESG data providers, so it can be expected that the results obtained using data from different providers may be similar but not the same. The Refinitiv ESG scores range from 0 to 100. To avoid any inconsistencies, observations (bonds) with any missing ESG values and ESG values equal to 0 have been removed from the analysis.

The results for the full sample have been reported in Table 14. The results in this table are comparable to the results in Table 5. The coefficient of ESG is negative and significant at lower quantiles of spread. This implies tha improvements in ESG reduce the bond spreads at lower quantiles of spread.

Next, the results for the brown and the green samples are reported in Tables 15 and 16 respectively. It can be observed from the results that even though the direction of the effect of ESG on bond spreads is similar to the main findings of the paper (reported in Tables 7 and 9), the effect is not significant. As the coefficients of the alternate ESG rating retains the same signs, it is safe to say that the direction of the impact (for brown and green companies) remains consistent irrespective of the measure of ESG used, the strength of the impact may vary with the ESG measure employed.

Table 14: Impact of ESG (Refinitiv) on bond spreads: Full sample

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
ESG	-0.001	-0.003*	-0.002*	-0.002	-0.001	-0.001	-0.001	-0.0002	0.001	0.001
	(0.002)	(0.002)	(0.001)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
ROA	-0.015***	-0.016***	-0.015***	-0.015***	-0.015***	-0.015***	-0.015***	-0.015***	-0.015***	-0.014***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
ICR	0.005***	0.004***	0.005***	0.005***	0.005***	0.005***	0.005***	0.006***	0.006***	0.006***
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)
GROWTH	0.0001	0.001***	0.001**	0.001***	0.0003	0.0001	0.00002	-0.0002	-0.001	-0.001
	(0.0003)	(0.0004)	(0.0003)	(0.0002)	(0.0002)	(0.0003)	(0.0002)	(0.0003)	(0.0004)	(0.0004)
LEV	0.005***	0.005**	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***	0.005***
	(0.001)	(0.002)	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
ln(MKTCAP)	-0.090***	-0.084***	-0.086***	-0.088***	-0.089***	-0.090***	-0.091***	-0.092***	-0.094***	-0.096***
	(0.009)	(0.012)	(0.010)	(0.008)	(0.008)	(0.007)	(0.006)	(0.011)	(0.009)	(0.009)
Constant	5.739***									
	(0.151)									
t2	0.497***	0.418***	0.446***	0.468***	0.484***	0.498***	0.508***	0.524***	0.550***	0.576***
	(0.016)	(0.014)	(0.015)	(0.014)	(0.014)	(0.014)	(0.021)	(0.019)	(0.019)	(0.027)
t3	0.101***	0.190***	0.159***	0.133***	0.115***	0.100***	0.089***	0.070***	0.041***	0.011
	(0.016)	(0.024)	(0.018)	(0.013)	(0.017)	(0.015)	(0.018)	(0.017)	(0.017)	(0.015)
t4	0.099***	0.105***	0.103***	0.101***	0.100***	0.099***	0.098***	0.097***	0.095***	0.092***
	(0.020)	(0.018)	(0.020)	(0.017)	(0.017)	(0.015)	(0.018)	(0.019)	(0.024)	(0.020)
t5	0.127***	0.155***	0.145***	0.137***	0.132***	0.127***	0.123***	0.118***	0.109***	0.099***
	(0.017)	(0.022)	(0.023)	(0.020)	(0.018)	(0.021)	(0.017)	(0.017)	(0.017)	(0.015)
t6	0.196***	0.186***	0.190***	0.192***	0.194***	0.196***	0.197***	0.199***	0.202***	0.205***
	(0.019)	(0.034)	(0.027)	(0.020)	(0.020)	(0.018)	(0.020)	(0.020)	(0.020)	(0.022)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Refinitiv (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 147 US corporate bonds from year 2017 to 2022. All the variables are described in Table 1. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

Table 15: Impact of ESG (Refinitiv) on bond spreads: Brown sample

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
ESG	-0.002	-0.005	-0.003	-0.002	-0.002	-0.002	-0.002	-0.001	0.0001	0.001
	(0.003)	(0.003)	(0.004)	(0.003)	(0.002)	(0.003)	(0.003)	(0.004)	(0.003)	(0.004)
ROA	-0.002	-0.161	0.001	-0.001	-0.001	-0.001	-0.002	-0.004	-0.005	-0.006**
	(0.003)	(0.005)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.005)	(0.003)
ICR	0.007***	0.003	0.007***	0.007***	0.007***	0.007***	0.007***	0.008***	0.008***	0.009***
	(0.002)	(0.005)	(0.002)	(0.002)	(0.003)	(0.002)	(0.002)	(0.002)	(0.003)	(0.002)
GROWTH	-0.001	0.006	-0.0005	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001**	-0.001
	(0.0005)	(0.001)	(0.001)	(0.001)	(0.0005)	(0.0004)	(0.001)	(0.0005)	(0.0004)	(0.001)
LEV	0.011***	-0.0003***	0.015***	0.013***	0.013***	0.012***	0.011**	0.008***	0.006	0.004
	(0.004)	(0.006)	(0.004)	(0.004)	(0.004)	(0.003)	(0.005)	(0.004)	(0.006)	(0.004)
ln(MKTCAP)	-0.273***	0.019*	-0.220**	-0.251**	-0.248**	-0.265***	-0.279***	-0.321***	-0.354***	-0.380***
	(0.093)	(0.094)	(0.100)	(0.103)	(0.101)	(0.097)	(0.092)	(0.117)	(0.125)	(0.131)
Constant	7.400***									
	(1.038)									
t2	0.283***	0.540***	0.404***	0.334***	0.340***	0.300***	0.269***	0.171***	0.095***	0.037
	(0.034)	(0.046)	(0.040)	(0.036)	(0.042)	(0.042)	(0.034)	(0.039)	(0.028)	(0.028)
t3	0.191***	0.368***	0.275***	0.226***	0.230***	0.203***	0.181***	0.113**	0.061	0.021
	(0.042)	(0.059)	(0.055)	(0.042)	(0.033)	(0.047)	(0.040)	(0.045)	(0.053)	(0.043)
t4	0.201***	0.351***	0.272***	0.230***	0.234***	0.211***	0.192***	0.135*	0.090	0.056
	(0.057)	(0.086)	(0.067)	(0.047)	(0.054)	(0.061)	(0.065)	(0.070)	(0.069)	(0.054)
t5	0.148**	0.222***	0.183***	0.162***	0.164***	0.153***	0.144**	0.116	0.094	0.077
	(0.061)	(0.057)	(0.058)	(0.052)	(0.059)	(0.059)	(0.066)	(0.076)	(0.066)	(0.070)
t6	0.216***	0.309***	0.260***	0.234***	0.237***	0.222***	0.211***	0.175***	0.148**	0.127*
	(0.066)	(0.065)	(0.059)	(0.061)	(0.059)	(0.053)	(0.073)	(0.063)	(0.067)	(0.074)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Refinitiv (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 61 US corporate bonds from year 2017 to 2022. All the variables are described in Table 3. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

Table 16: Impact of ESG (Refinitiv) on bond spreads: Green sample

	OLS	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread										
ESG	0.005	0.008	0.007	0.006	0.005	0.005	0.004	0.004	0.003	0.003
	(0.005)	(0.010)	(0.006)	(0.005)	(0.007)	(0.007)	(0.005)	(0.003)	(0.004)	(0.005)
ROA	-0.023***	-0.030***	-0.027***	-0.025***	-0.024***	-0.022***	-0.021***	-0.020***	-0.019***	-0.017***
	(0.003)	(0.008)	(0.006)	(0.003)	(0.004)	(0.004)	(0.004)	(0.003)	(0.005)	(0.006)
ICR	0.001	0.007	0.004	0.003	0.002	0.0001	-0.0005	-0.001	-0.002	-0.004
	(0.002)	(0.005)	(0.003)	(0.003)	(0.003)	(0.001)	(0.002)	(0.002)	(0.003)	(0.003)
GROWTH	-0.001	-0.004**	-0.003*	-0.002	-0.001	-0.0001	0.0002	0.001	0.001*	0.002**
	(0.001)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
LEV	0.007***	0.010**	0.009***	0.008***	0.008**	0.007***	0.007***	0.006***	0.006**	0.005*
	(0.002)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.002)	(0.002)	(0.003)	(0.003)
ln(MKTCAP)	-0.040	-0.014	-0.024	-0.033	-0.036	-0.044	-0.047	-0.050*	-0.056**	-0.062*
	(0.034)	(0.054)	(0.062)	(0.031)	(0.033)	(0.033)	(0.034)	(0.027)	(0.026)	(0.032)
Constant	4.621***									
	(0.510)									
t2	0.423***	0.411***	0.416***	0.420***	0.421***	0.425***	0.426***	0.427***	0.430***	0.432***
	(0.040)	(0.075)	(0.057)	(0.040)	(0.040)	(0.035)	(0.040)	(0.033)	(0.044)	(0.040)
t3	0.125***	0.222***	0.184***	0.153***	0.139***	0.110***	0.100***	0.088***	0.067*	0.045
	(0.029)	(0.084)	(0.056)	(0.033)	(0.035)	(0.030)	(0.027)	(0.023)	(0.035)	(0.037)
t4	0.032	0.047	0.041	0.037	0.034	0.030	0.029	0.027	0.024	0.021
	(0.039)	(0.066)	(0.047)	(0.041)	(0.040)	(0.040)	(0.041)	(0.034)	(0.049)	(0.046)
t5	0.134*	0.250***	0.204***	0.168***	0.151***	0.117***	0.105**	0.091***	0.066	0.040
	(0.032)	(0.050)	(0.036)	(0.035)	(0.026)	(0.041)	(0.046)	(0.034)	(0.049)	(0.037)
t6	0.071	0.008	0.033	0.052	0.062	0.080	0.087**	0.094***	0.108**	0.122***
	(0.048)	(0.146)	(0.076)	(0.077)	(0.053)	(0.051)	(0.034)	(0.024)	(0.045)	(0.033)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on model 4. The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Refinitiv (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), and dummy variables for each year t2-t6. The sample includes 66 US corporate bonds from year 2017 to 2022. All the variables are described in Table 3. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

6.3 Robustness check - III: Using an alternate estimation method

This section reports and discusses the results of the panel quantile estimation method developed by Koenker (2004). Essentially, this method estimates the regression coefficients considering that the individual fixed effects have the same effect in each quantile. This method uses a penalized fixed effects estimation approach in which the individual fixed effects are shrunk toward a common value using a penalty term.

The results in Tables 17, 18, and 19 are similar to the results in 5, 7, and 9. The coefficient of ESG is significant and negative only for the 10th quantile (the lower extreme) implying that improvements in ESG ratings reduce the bond spreads at low values of bond spreads while at higher quantiles of bond spreads, the effect becomes positive but is insignificant. The coefficients of ESG for the brown sample (as reported in Table 18) are negative - indicating that improvements in ESG ratings result in a reduction in bond spreads. This result attests to the main results and results from other robustness exercises presented in the paper. Finally, the results for the green sample in Table 19 indicate that the coefficient of ESG takes positive values throughout the distribution of bond spreads. This result is also aligned with the main result of the paper and the results of other robustness exercises.

Table 17: Impact of ESG on bond spreads

	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread									
ESG	-0.009	-0.026*	-0.019	-0.003	0.002	0.0005	-0.002	-0.003	0.011
	(0.014)	(0.015)	(0.014)	(0.013)	(0.012)	(0.161)	(0.011)	(0.012)	(0.012)
lnISSUESIZE	-0.095***	-0.095***	-0.100***	-0.097***	-0.095***	-0.089***	-0.089***	-0.0856***	-0.074***
	(0.011)	(0.010)	(0.009)	(0.008)	(0.008)	(0.012)	(0.008)	(0.008)	(0.009)
RATING	-0.113***	-0.116***	-0.123***	-0.125***	-0.126***	-0.128***	-0.128***	-0.135***	-0.142***
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.008)	(0.005)	(0.007)	(0.007)
ln(MKTCAP)	-0.094***	-0.089***	-0.079***	-0.075***	-0.076***	-0.078***	-0.084***	-0.0792***	-0.081***
	(0.010)	(0.009)	(0.008)	(0.007)	(0.007)	(0.005)	(0.006)	(0.008)	(0.007)
ROA	-0.016***	-0.015***	-0.015***	-0.016***	-0.017***	-0.016***	-0.015***	-0.013***	-0.013***
	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.007)	(0.002)	(0.002)	(0.011)
ICR	-0.001	0.0003	0.002	0.003**	0.004***	0.004***	0.003***	0.003**	0.004**
	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)
LEV	0.002**	0.001	0.001*	0.001*	0.001**	0.001	0.001	0.001	0.0004
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
GROWTH	0.0001	-0.0003	0.0001	0.0004	0.0004	0.001	0.001	0.0005	0.0002
	(0.001)	(0.0004)	(0.0003)	(0.0003)	(0.0003)	(0.001)	(0.0004)	(0.0005)	(0.001)
MATURITY	0.023***	0.021***	0.021***	0.020***	0.020***	0.019***	0.018***	0.017***	0.017***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.0004)	(0.001)	(0.002)	(0.0005)
Constant	8.210***	8.425***	8.486***	8.418***	8.418***	8.467***	8.606***	8.670***	8.623***
	(0.213)	(0.199)	(0.184)	(0.170)	(0.169)	(0.001)	(0.152)	(0.161)	(0.002)
t2	0.422***	0.429***	0.463***	0.492***	0.538***	0.533***	0.575***	0.616***	0.618***
	(0.027)	(0.023)	(0.024)	(0.024)	(0.025)	(0.026)	(0.029)	(0.040)	(0.044)
t3	0.157***	0.166***	0.183***	0.173***	0.157***	0.130***	0.113***	0.085***	0.023
	(0.028)	(0.023)	(0.021)	(0.019)	(0.020)	(0.020)	(0.022)	(0.030)	(0.029)
t4	0.066**	0.114***	0.159***	0.168***	0.173***	0.177***	0.154***	0.134***	0.092**
	(0.027)	(0.032)	(0.027)	(0.028)	(0.030)	(0.025)	(0.023)	(0.032)	(0.039)
t5	0.129***	0.180***	0.203***	0.202***	0.190***	0.167***	0.151***	0.124***	0.040
	(0.033)	(0.032)	(0.026)	(0.024)	(0.025)	(0.024)	(0.023)	(0.030)	(0.033)
t6	0.208***	0.257***	0.267***	0.254***	0.242***	0.224***	0.217***	0.197***	0.146***
	(0.039)	(0.030)	(0.025)	(0.025)	(0.026)	(0.027)	(0.026)	(0.033)	(0.036)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on panel quantile fixed effects regression technique proposed by Koenker (2004). The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Bloomberg (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), natural logarithm of the size of issue (lnISSUESIZE), credit rating provided by Moody's (RATING), maturity in years (MATURITY), and dummy variables for each year t2-t6. The sample includes 147 US corporate bonds from year 2017 to 2022. All the variables are described in Table 3. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

Table 18: Impact of ESG on bond spreads: Brown sample

	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread									
ESG	-0.071	-0.063	-0.081*	-0.092**	-0.088**	-0.070*	-0.073**	-0.047	-0.069*
	(0.060)	(0.055)	(0.047)	(0.041)	(0.038)	(0.383)	(0.035)	(0.033)	(0.036)
lnISSUESIZE	-0.010	0.007	-0.001	-0.013	-0.010	-0.008	-0.006	-0.011	0.002
	(0.026)	(0.020)	(0.018)	(0.016)	(0.015)	(0.037)	(0.017)	(0.020)	(0.022)
RATING	-0.089**	-0.090***	-0.082***	-0.091***	-0.083***	-0.082***	-0.080***	-0.098***	-0.084***
	(0.035)	(0.031)	(0.031)	(0.031)	(0.029)	(0.015)	(0.031)	(0.030)	(0.029)
ln(MKTCAP)	-0.179***	-0.156***	-0.139***	-0.145***	-0.154***	-0.176***	-0.201***	-0.179***	-0.182***
	(0.058)	(0.050)	(0.052)	(0.051)	(0.050)	(0.029)	(0.047)	(0.043)	(0.039)
ROA	-0.002	-0.004	-0.004	-0.001	-0.0001	-0.002	-0.004	-0.004	-0.005
	(0.004)	(0.004)	(0.004)	(0.004)	(0.004)	(0.047)	(0.004)	(0.003)	(0.004)
ICR	0.009*	0.007**	0.005*	0.004	0.004	0.008**	0.012***	0.013***	0.012***
	(0.004)	(0.003)	(0.003)	(0.003)	(0.003)	(0.004)	(0.004)	(0.003)	(0.004)
LEV	0.015***	0.010**	0.007**	0.009***	0.008**	0.009***	0.009***	0.009***	0.008***
	0.005)	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)	(0.003)
GROWTH	-0.0001	-0.0003	0.0002	0.00002	-0.0003	-0.001	-0.001	-0.002***	-0.001
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.003)	(0.001)	(0.001)	(0.001)
MATURITY	0.017***	0.014**	0.014**	0.017***	0.016***	0.015***	0.012**	0.010	0.007
	(0.006)	(0.006)	(0.006)	(0.005)	(0.005)	(0.001)	(0.006)	(0.006)	(0.008)
Constant	6.936***	6.700***	6.908***	7.202***	7.258***	7.414***	7.782***	7.862***	7.720***
	(0.658)	(0.472)	(0.450)	(0.417)	(0.406)	(0.005)	(0.395)	(0.430)	(0.450)
t2	0.364***	0.417***	0.376***	0.375***	0.340***	0.296***	0.219***	0.152***	0.155***
	(0.086)	(0.070)	(0.063)	(0.054)	(0.046)	(0.049)	(0.055)	(0.045)	(0.052)
t3	0.327***	0.307***	0.234***	0.256***	0.241***	0.215***	0.153**	0.119**	0.144***
	(0.093)	(0.072)	(0.065)	(0.058)	(0.054)	(0.060)	(0.062)	(0.057)	(0.055)
t4	0.284***	0.287***	0.271***	0.315***	0.269***	0.225***	0.169*	0.135	0.250***
	(0.106)	(0.102)	(0.096)	(0.083)	(0.075)	(0.079)	(0.087)	(0.088)	(0.074)
t5	0.168*	0.183*	0.163*	0.188**	0.198**	0.204**	0.138*	0.149*	0.203***
	(0.086)	(0.103)	(0.096)	(0.085)	(0.082)	(0.080)	(0.082)	(0.086)	(0.075)
t6	0.279***	0.307***	0.289***	0.311***	0.289***	0.248***	0.200**	0.156**	0.251***
	(0.092)	(0.099)	(0.099)	(0.087)	(0.076)	(0.081)	(0.090)	(0.079)	(0.071)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on panel quantile fixed effects regression technique proposed by Koenker (2004). The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Bloomberg (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), natural logarithm of the size of issue (lnISSUESIZE), credit rating provided by Moody's (RATING), maturity in years (MATURITY), and dummy variables for each year t2-t6. The sample includes 61 US corporate bonds from year 2017 to 2022. All the variables are described in Table 3. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

Table 19: Impact of ESG on bond spreads: Green sample

	10th quantile	20th quantile	30th quantile	40th quantile	50th quantile	60th quantile	70th quantile	80th quantile	90th quantile
DV: ln Lead Bond Spread									
ESG	0.004	0.025	0.067*	0.065**	0.062**	0.065**	0.084***	0.099***	0.107***
	(0.048)	(0.040)	(0.037)	(0.031)	(0.027)	(0.029)	(0.028)	(0.024)	(0.024)
lnISSUESIZE	0.070**	0.061**	0.035*	0.034**	0.028**	0.028**	0.024*	0.023*	0.012
	(0.030)	(0.024)	(0.020)	(0.014)	(0.012)	(0.012)	(0.013)	(0.013)	(0.019)
RATING	-0.083***	-0.082***	-0.084***	-0.088***	-0.080***	-0.081***	-0.084***	-0.090***	-0.087***
	(0.015)	(0.012)	(0.012)	(0.012)	(0.010)	(0.011)	(0.010)	(0.012)	(0.013)
ln(MKTCAP)	-0.008	-0.047	-0.059	-0.066*	-0.068**	-0.059**	-0.056*	-0.041	-0.060
	(0.043)	(0.039)	(0.040)	(0.038)	(0.033)	(0.030)	(0.030)	(0.039)	(0.049)
ROA	-0.032***	-0.017**	-0.016***	-0.013***	-0.015***	-0.015***	-0.011***	-0.009***	-0.009***
	(0.011)	(0.007)	(0.006)	(0.004)	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)
ICR	0.002	-0.001	-0.002	-0.003	-0.003	-0.004	-0.006*	-0.005*	-0.004
	(0.004)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
LEV	0.011***	0.009***	0.008***	0.008***	0.009***	0.009***	0.008***	0.008***	0.007***
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.002)
GROWTH	-0.001	-0.001	0.000	-0.001	-0.0004	0.0009	0.0004	-0.0001	-0.00001
	(0.002)	(0.002)	(0.002)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
MATURITY	0.029***	0.029***	0.026***	0.023***	0.023***	0.021***	0.019***	0.019***	0.017***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
Constant	2.998***	3.625***	4.340***	4.603***	4.690***	4.739***	4.915***	4.810***	5.262***
	(0.903)	(0.761)	(0.719)	(0.607)	(0.517)	(0.444)	(0.417)	(0.491)	(0.659)
t2	0.379***	0.364***	0.421***	0.452***	0.472**	0.423***	0.380***	0.425***	0.489***
	(0.088)	(0.072)	(0.076)	(0.068)	(0.066)	(0.058)	(0.053)	(0.052)	(0.053)
t3	0.183**	0.103	0.119*	0.140**	0.131	0.100	0.040	0.031	0.060
	(0.088)	(0.071)	(0.061)	(0.056)	(0.060)	(0.062)	(0.053)	(0.042)	(0.043)
t4	-0.071	-0.020	0.034	0.047	0.009	-0.014	-0.047	-0.031	0.051
	(0.097)	(0.080)	(0.071)	(0.071)	(0.077)	(0.078)	(0.065)	(0.054)	(0.063)
t5	0.093	0.106*	0.090	0.118**	0.101	0.031	-0.044	-0.022	-0.013
	(0.076)	(0.062)	(0.061)	(0.059)	(0.062)	(0.069)	(0.061)	(0.052)	(0.050)
t6	-0.037	0.117	0.088	0.139**	0.111*	0.028	-0.038	-0.008	0.047
	(0.206)	(0.078)	(0.069)	(0.063)	(0.065)	(0.071)	(0.058)	(0.050)	(0.046)
Bond FEs	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: This table presents the regression results based on Equation 1 and results of panel quantile fixed effects model after split-panel jackknife bias correction based on panel quantile fixed effects regression technique proposed by Koenker (2004). The dependent variable (DV) is the natural logarithm of one-month-ahead bond spreads. The explanatory variables are Environmental, Social, and Governance ratings provided by Bloomberg (ESG), Return on Assets (ROA), Interest Coverage Ratio (ICR), Sales growth (GROWTH), Total debt to total assets (LEV), the natural logarithm of market capitalization (ln(MKTCAP)), natural logarithm of the size of issue (lnISSUESIZE), credit rating provided by Moody's (RATING), maturity in years (MATURITY), and dummy variables for each year t2-t6. The sample includes 66 US corporate bonds from year 2017 to 2022. All the variables are described in Table 3. The standard errors are reported in parentheses. All model specifications include fixed -effects at the bond level.
*,**,*** signify the significance levels at 10, 5 and 1% thresholds, respectively.

7 Conclusion

ESG is increasingly becoming the most crucial indicator of corporate sustainability. Many credit rating agencies now provide their own ESG ratings. Fitch developed its Sustainable Fitch platform, while Moody's and S&P acquired support for similar capabilities. The growing interest of credit rating agencies in acquiring ESG data providers also illustrates the importance of sustainability in credit markets. This evolution in the role of ESG in credit markets poses the question - of how the credit markets reflect the ESG ratings (a proxy for sustainability practices adopted by firms) assigned to companies. This paper addresses this question and brings forward three novel insights about the relationship between ESG and credit risk (proxied by bond spreads). First, the ESG-bond spreads relationship is compared between the heavily polluting sample (comprising of bonds belonging to heavily emitting companies) and the lightly polluting sample (comprising of bonds belonging to lightly emitting companies). Then, the relationship between the weighted E, S, and G pillar with the bond spreads is studied to gauge the importance of each pillar in determining the spreads for different samples. The paper uses weighted pillars as the weighted pillars are comparable across industries and companies. This is one of the few studies highlighting the importance of and accounting for weighted ESG pillar scores instead of unweighted scores. Lastly, the paper investigates if the ESG-bond spread relationship varies across quantiles (distribution of bond spreads).

The findings reveal that the relationship between ESG and bond spreads is negative for the brown sample while positive for the green sample. This implies that for the brown sample, improvements in ESG lead to a risk mitigation effect (manifested in the form of a decrease in the bond spreads). On the other hand, upgrades in the ESG ratings are penalized in the bond markets (in the form of higher spreads) in the case of the green sample (reflected in the positive coefficients of ESG). This finding implies that investors demand higher returns on bonds of lightly emitting companies improving their ESG performance. Though there is scant work in the literature to back this finding, the paper by Li and

Adriaens (2024) finds that the impact of ESG on bond spreads is positive for a sample of companies in lightly polluting sectors. And, Palmieri et al. (2023)'s findings suggest that belonging to a low-emitting industry has no significant impact on a company's probability of default. These findings in the recent literature substantiate the results of this paper by providing evidence that green companies are deemed safe by investors and that any efforts towards improving ESG performance may be considered wasteful and therefore, penalized.

Next, the findings highlight that the weighted E pillar is the most important in determining the bond spreads for heavily emitting companies. This is because the weighted E pillar is the only pillar with a significant mean impact on bond spreads. Moreover, the panel quantile regression results reveal that the coefficient of the weighted E pillar is negative and decreases steeply (becomes more negative). It is also significant for values of bond spreads above the 50th quantile. This result implies that improvements in the weighted E pillar, reduce the credit risk associated with bonds of heavily emitting firms, specifically for higher bond spreads.

For the lightly emitting sample, all three pillars are positive across the distribution of the bond spreads. All three pillars have a significant and positive impact on bond spreads indicating that credit risk associated with bonds of lightly emitting firms increases with improvements in weighted pillar scores. The coefficients of the weighted E and S pillars across the quantiles are decreasing while the coefficients of the weighted G pillar are increasing. While an improvement in the weighted G pillar has the maximum mean impact on the bond spreads, if quantile regression results are considered, it can be noted that the effect of the G pillar is only prominent in the mid-quantiles. This result underscores the advantage of using quantile regression vis-a-vis OLS.

The effect of ESG on bond spreads is studied for heavily polluting and lightly polluting companies. The contrasting results for the two sub-samples bring to light that the ESG-credit risk relationship is heterogeneous across industries. The disentangling of the impact of ESG (in its pillars) on bond spreads, this paper reduces information asymmetry by highlighting the importance of each pillar (especially using weighted pillars) in determining the bond spreads. Finally, the ESG-credit risk relationship varies across the spectrum of bond spreads.

The results reported in this paper are of use to investors, policymakers, and businesses. As investors become more knowledgeable about the nuances of ESG impacts, they are better able to diversify their portfolios, mitigating the risk of overexposure to sectors whose ESG issues are highly sensitive. Moreover, in industries that adapt to ESG concerns, investors may see growth opportunities and competitive advantages. By gaining an understanding of which sectors benefit from improvements in ESG, investors can advocate a push towards higher sustainability standards. The insights from this analysis can enable policymakers to formulate policies to drive desirable investor behavior. Finally, if businesses understand how investors react to their ESG practices, they can attract more capital at lower costs by formulating policies that are best suited to their industry type.

References

Apergis, N., Poufinas, T., and Antonopoulos, A. (2022). Esg scores and cost of debt. *Energy Economics*, 112:106186.

Atif, M. and Ali, S. (2021). Environmental, social and governance disclosure and default risk. *Business Strategy and the Environment*, 30(8):3937–3959.

Balvers, R., Du, D., and Zhao, X. (2017). Temperature shocks and the cost of equity capital: Implications for climate change perceptions. *Journal of Banking & Finance*, 77:18–34.

Barth, F., Hübel, B., and Scholz, H. (2022). Esg and corporate credit spreads. *The Journal of Risk Finance*.

Bauer, M. D., Huber, D., Rudebusch, G. D., and Wilms, O. (2022). Where is the carbon premium? global performance of green and brown stocks. *Journal of Climate Finance*, 1:100006.

Berg, F., Heeb, F., and Kölbel, J. F. (2022). The economic impact of esg rating changes. *Available at SSRN 4088545*.

Chava, S. (2014). Environmental externalities and cost of capital. *Management science*, 60(9):2223–2247.

Chen, L. H. and Silva Gao, L. (2012). The pricing of climate risk. *Journal of Financial and Economic Practice, Vol12 (2), Spring*, pages 115–131.

Dhaene, G. and Jochmans, K. (2015). Split-panel jackknife estimation of fixed-effect models. *The Review of Economic Studies*, 82(3):991–1030.

Garvey, G. T., Iyer, M., and Nash, J. (2018). Carbon footprint and productivity: Does the" e" in esg capture efficiency as well as environment? *Journal of Investment Management*, 16(1):59–69.

Ginglinger, E. and Moreau, Q. (2019). Climate risk and capital structure. *Université Paris-Dauphine Research Paper*, (3327185).

Gull, A. A., Atif, M., Ahsan, T., and Derouiche, I. (2022). Does waste management affect firm performance? international evidence. *Economic Modelling*, 114:105932.

Halling, M., Yu, J., and Zechner, J. (2021). Primary corporate bond markets and social responsibility. *Swedish House of Finance Research Paper*, (20-13).

In, S. Y., Park, K. Y., and Monk, A. (2017). Is "being green" rewarded in the market? an empirical investigation of decarbonization risk and stock returns. *International Association for Energy Economics (Singapore Issue)*, 46(48):46–48.

Jang, G.-Y., Kang, H.-G., Lee, J.-Y., and Bae, K. (2020). Esg scores and the credit market. *Sustainability*, 12(8):3456.

Kim, Y.-B., An, H. T., and Kim, J. D. (2015). The effect of carbon risk on the cost of equity capital. *Journal of Cleaner Production*, 93:279–287.

Kling, G., Volz, U., Murinde, V., and Ayas, S. (2021). The impact of climate vulnerability on firms' cost of capital and access to finance. *World Development*, 137:105131.

Klock, M. S., Mansi, S. A., and Maxwell, W. F. (2005). Does corporate governance matter to bondholders? *Journal of financial and quantitative analysis*, 40(4):693–719.

Koenker, R. (2004). Quantile regression for longitudinal data. *Journal of multivariate analysis*, 91(1):74–89.

Li, D. and Adriaens, P. (2024). Deconstruction of esg impacts on us corporate bond pricing: The cost of capital benefits across industry sectors. *Journal of Management in Engineering*, 40(1):04023052.

Li, Q., Li, T., and Zhang, Y. (2024). Esg performance, heterogeneous creditors, and bond financing costs: Firm-level evidence. *Finance Research Letters*, page 105527.

Lian, Y., Ye, T., Zhang, Y., and Zhang, L. (2023). How does corporate esg performance affect bond credit spreads: Empirical evidence from china. *International Review of Economics & Finance*, 85:352–371.

Machado, J. A. and Silva, J. S. (2019). Quantiles via moments. *Journal of Econometrics*, 213(1):145–173.

Madison, N. and Schiehll, E. (2021). The effect of financial materiality on esg performance assessment. *Sustainability*, 13(7):3652.

Morrone, D., Schena, R., Conte, D., Bussoli, C., and Russo, A. (2022). Between saying and doing, in the end there is the cost of capital: Evidence from the energy sector. *Business Strategy and the Environment*, 31(1):390–402.

Ng, A. C. and Rezaee, Z. (2015). Business sustainability performance and cost of equity capital. *Journal of Corporate Finance*, 34:128–149.

Oikonomou, I., Brooks, C., and Pavelin, S. (2014). The effects of corporate social performance on the cost of corporate debt and credit ratings. *Financial Review*, 49(1):49–75.

Palmieri, E., Geretto, E. F., and Polato, M. (2023). Esg default risk mitigation effect: A time-sectorial analysis. In *New challenges for the banking industry: Searching for balance between corporate governance, sustainability and innovation*, pages 79–98. Springer.

Qian, X., Ding, H., and Ding, Z. (2023). Governmental inspection and firm environmental protection expenditure: Evidence from china. *Economic Modelling*, 123:106284.

Van Hoang, T. H., Pham, L., and Nguyen, T. T. P. (2023). Does country sustainability improve firm esg reporting transparency? the moderating role of firm industry and csr engagement. *Economic Modelling*, 125:106351.

Yang, Y., Du, Z., Zhang, Z., Tong, G., and Zhou, R. (2021). Does esg disclosure affect corporate-bond credit spreads? evidence from china. *Sustainability*, 13(15):8500.

Zumente, I. and Lāce, N. (2021). Esg rating—necessity for the investor or the company? *Sustainability*, 13(16):8940.