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The Impact of Environmental Performance on the Debt Cost

Shujie Chen[1, *]

[1] A. Gary Anderson Graduate School of Management, *University of California, Riverside*, *United States*
*Corresponding author: schen484@ucr.edu

Abstract:

This study aims to explore whether enterprises with stronger environmental performance can benefit from lower debt financing costs, and it pay particular attention to the possible differences between high-pollution industries and low-pollution industries. The study utilized a panel dataset of 255 US-listed companies from 2010 to 2023, combining Compustat financial data with MSCI ESG environmental performance scores. Debt costs are calculated from dividing interest expenses by total debt. The model also uses enterprise size, leverage ratio and profitability as control variables. Mitigate unobserved heterogeneity by estimating panel regression that includes fixed effects of enterprises and years. The results of the baseline model indicate that there is a significant negative correlation between environmental performance and debt costs, suggesting that creditors tend to offer more favorable financing to enterprises with stronger environmental practices. The interaction model did not find significant differences in high-pollution industries, while sub-sample regression showed that this relationship was stronger and more stable among enterprises in low-pollution industries. These findings suggest that the financial benefits brought by environmental responsibility are obvious, but their intensity may depend on the industry context. This study contributes to the literature in the ESG and corporate finance fields by providing strong evidence that environmental performance can reduce debt costs, highlighting its strategic importance to managers and policymakers.

Keywords: ESG, cost of debt, high-polluting industries.

1. Introduction

In the last few years, environmental and climate-related issues have become more important in financial markets. This has changed how investors and lenders look at how well a company is doing. Companies are being judged more and more not just on how much money they make and how much they can grow, but also on how well they can handle environmental risks and show that they use sustainable practices. This

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change is a sign of growing worries about climate change, unclear rules, and the bad effects on a company's reputation that come from bad environmental management. Consequently, environmental, social, and governance (ESG) factors have become pivotal in capital allocation decisions, especially as creditors aim to mitigate exposure to companies that might incur elevated compliance costs or environmental liabilities.

There is a lot of information in the literature about how environmental performance affects the value of a company. Several large-scale studies demonstrate positive effects, such as Abrams et al. found higher valuations for companies efficiently managing greenhouse gas emissions across 345 Fortune 500 companies [1], while Dal Maso et al. documented positive relationships between environmental performance and market-to-book value using 8,112 US firm observations [2]. Konar and Cohen quantified this relationship, finding a 10% reduction in toxic emissions resulted in a $34 million increase in market value among S&P 500 firms [3].

However, there is less agreement about how it affects the cost of debt. Some research indicates that environmentally responsible companies have lower debt costs, providing empirical evidences [4, 5, 6, 7]. Whereas other studies indicate ambiguous or minimal impacts [8, 9]. Furthermore, insufficient attention has been directed towards investigating whether this relationship varies across industries with differing degrees of environmental risk exposure. Companies in sectors that produce a lot of pollution, like energy, mining, and chemicals, may be watched more closely by both regulators and investors. This means that in these cases, good environmental performance could lead to bigger financial gains.

The aim of this research is to assess whether companies exhibiting superior environmental performance gain advantages from reduced debt financing costs, and whether this correlation is dependent on the degree of environmental risk associated with the industries in which these companies operate.

2. Theoretical Model and Hypotheses

Environmental performance is having a bigger and bigger effect on how companies get money because lenders look at environmental risks when deciding how likely a company is to default and how creditworthy it is. Companies that don't follow environmental rules are more likely to face fines, lawsuits, and damage to their reputation, all of which raise the risk and uncertainty of doing business. On the other hand, companies that do better for the environment lower these risks and often get lower borrowing costs as a reward. Strong environmental performance can also enhance reputation, signal managerial competence, and improve access to sustainability-linked financing instruments, such as green bonds or preferential loan agreements.

In theory, the connection between environmental performance and debt costs is based on lowering risk. Lenders change interest rates based on how risky they think a loan is. Companies that are environmentally responsible are thought to be less likely to face unexpected costs or shocks that destroy value. Better environmental performance should lower effective interest rates by lowering creditors' risk premiums.

However, the evidences provided by research are not consistent. Bauer and Hann documented lower debt costs for 582 U.S. corporations (1995-2006) [4], while Chiesa et al. found similar effects across 5,260 EU and U.S. bonds (2016-2018) [5]. Sharfman et al. confirmed reduced capital costs for 267 firms [6], and Jin et al. reported clear associations with lower borrowing costs and fewer restrictive covenants [7]. However, contradictory evidence exists: Karaman et al. found no significant direct effect across 38,127 firm-year observations globally [8], and Hoepner et al. found no conclusive firm-level effects across 470 international loan agreements [9].

In addition, some findings indicating that industry context influences the strength of the relationship. Effects are stronger in environmentally sensitive industries [10], sectors with stricter regulation [11], and among the most polluting industries [12]. Regulators and investors are paying more attention to industries that pollute a lot, like mining, energy, and chemicals. In these industries, bad environmental management can cost a lot of money and damage a company's reputation, which makes creditors more wary of environmental risks. As a result, companies in industries that pollute more may see bigger financial benefits from better environmental performance than companies in industries that pollute less, where environmental risks are less serious and creditors are less likely to respond.

Based on these evidences, the study formulates two hypotheses:

Hypothesis 1 (H1): Companies that do better for the environment pay less for debt.

Hypothesis 2 (H2): The adverse correlation between environmental performance and the cost of debt is more pronounced in high-polluting industries compared to low-polluting industries.

3. Data and Method

This study utilizes a quantitative research design to examine whether companies exhibiting superior environmental performance incur reduced debt financing costs, with a specific focus on the potential amplification of this relationship within high-polluting sectors. The main financial data came from the Compustat North America database, which has standardized annual financial statement infor-

mation for US publicly traded companies. The study period from 2010 to 2023 is chosen because it encompasses a significant era during which environmental, social, and governance (ESG) issues emerged in capital markets and avoids the impact of the financial crisis. The environmental performance measure obtained from MSCI's ESG datasets, which give monthly firm-level environmental scores. To make it match the Compustat database, it was transformed into annual data.

Companies were matched using their CUSIP numbers and financial years in order to align the financial and ESG datasets. The final sample does not include companies that do not have data on important variables like environmental scores, total debt, or interest expenses. Companies with very high debt costs were also left out, because they may cause a big bias in the analysis results. After using these criteria, the panel dataset has about 255 firms and 3,570 firm-year observations. This shows a wide range of industries.

The dependent variable is the cost of debt, which is measured by the ratio of interest expense to total debt for a specific fiscal year. This metric reflects the average effective interest rate paid by a company and has been extensively utilized in previous studies regarding financing expenses. The main independent variable is the environmental score (env_score), which shows how well a company does in areas like emissions, resource efficiency, and environmental management. Higher scores mean better environmental performance.

Control variables are added to take into account other factors that affect debt costs. The natural logarithm of total assets (log_assets) is used to measure firm size. This takes into account the benefits of larger firms, such as economies of scale and a better reputation. The ratio of total debt to total assets is called leverage. This shows how capital structure affects debt costs. Return on assets (ROA), which is net income divided by total assets, is used to measure a company's profitability and ability to pay back debts. In the field of corporate finance, these factors have always been seen as important indicators of financing costs.

To investigate the variation in the impact of environmental performance according to industry pollution intensity, a classification at the industry level utilizing Standard Industrial Classification (SIC) codes was implemented. To capture this difference, a binary variable called "high_pollute" was made, and an interaction term between environmental performance and high_pollute was made to formally test for different effects in industries between high-polluting and non-polluting.

The primary model utilized in this research is a panel regression incorporating firm and year fixed effects. Panel regressions are particularly well suited for this analysis because they exploit both the cross-sectional and time-series dimensions of the data, enabling the study to control for unobserved heterogeneity across firms that does not vary over time. The model uses a fixed-effects specification to get rid of the effects of firm-specific characteristics that don't change over time, like long-standing governance structures, industry memberships, or cultural orientations. These characteristics could otherwise skew the estimated link between environmental performance and financing costs. Year fixed effects also take into account shocks that affect the whole economy, like changes in monetary policy or the state of the financial markets, that could affect all firms at the same time. These changes make sure that the estimated coefficients show how environmental performance and financing costs change over time within a firm, not false correlations between different firms.

The baseline regression model is defined as follows:

$$\text{CostofDebt}_{it} = \beta_1 \text{EnvScore}_{it} + \gamma X_{it} + \alpha_i + \lambda_t + ?_{it} \quad (1)$$

where i stands for companies, t stands for years, CostofDebt_{it} is the interest expense divided by the total debt, and EnvScore_{it} is the company's environmental performance. The vector X_{it} has the control variables, which are firm size (the log of total assets), leverage (the total debt over total assets), and profitability (the return on assets). The letters α_i and λ_t stand for fixed effects for firms and years, respectively, and $?_{it}$ is the idiosyncratic error term. The parameter of interest in this baseline model is β_1. A notably negative value of β_1 would corroborate Hypothesis 1, which posits that firms exhibiting superior environmental performance encounter reduced debt costs.

To further examine the variation of environmental performance effects across industries, an interaction term involving high-polluting industries is incorporated into the extended model. This specification is written as:

$$\begin{aligned}\text{CostofDebt}_{it} &= \beta_1 \text{EnvScore}_{it} + \\ &\beta_2 (\text{EnvScore}_{it} \times \text{HighPollute}_i) + \\ &\gamma X_{it} + \alpha_i + \lambda_t + ?_{it}\end{aligned} \quad (2)$$

In this specification, β_1 quantifies the impact of environmental performance on the cost of debt for firms in low-polluting sectors, whereas β_2 assesses whether this impact is significantly distinct for firms in high-polluting sectors. A negative and statistically significant β_2 would substantiate Hypothesis 2, which asserts that the advantages of environmental performance in mitigating debt costs are more pronounced in high-polluting industries where lenders exhibit heightened sensitivity to environmental risks.

In addition, the study utilizes a subsample analysis as an

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ancillary method to assess heterogeneity. The sample is categorized into two groups according to the high_pollute classification: one group consists of firms operating in high-polluting industries, while the other group consists of firms engaged in low-polluting industries. Subsequent regressions are calculated for each group utilizing the identical fixed-effects specification as the baseline model. This approach facilitates a direct comparison of the environmental performance coefficient among subsamples, thereby yielding supplementary evidence concerning the heterogeneity of the effect.

4. Descriptive Analysis

Before conducting regression analysis, it is beneficial to review the descriptive statistics of the study's variables. Table 1 shows the summary statistics for the most important variables, and Figures 1–3 show how they are distributed in graphs. These results provide preliminary insights into the sample's characteristics and the feasibility of the proposed hypotheses.

Table 1. Descriptive analysis for each variable

Variable	Min	Median	Mean	Max
fyear	2010	2016	2016	2023
leverage	0.012	0.311	0.319	2.439
roa	-0.490	0.055	0.060	0.511
env_score	1.000	4.000	4.043	7.000
cost_debt	0.001	0.040	0.041	0.097
log_assets	7.351	10.023	10.194	14.698

As table 1 shown, the sample covers the years 2010 to 2023, which means that the dataset includes more than ten years of firm-level observations during which environmental, social, and governance issues became more important in financial markets. The average cost of debt is about 0.041, and the median is 0.040. This means that companies pay about four percent of their debt obligations on average. The average environmental score (env_score) for the explanatory and control variables is 4.04, with values ranging from 1 to 7. This shows that there is a lot of difference between companies in terms of how well they do in terms of the environment. This variation allows for the examination of whether disparities in environmental practices result in differing financing outcomes. The logarithm of total assets, which ranged from 7.351 to 14.698, showed that the sample included both small and very large firms. The average leverage is 0.32, which means that companies use debt to pay for about a third of their assets. However, the highest value of 2.44 shows that some companies are very highly leveraged. The mean return on assets (ROA) for profitability is 0.059, with both negative and positive extremes. This shows that financial performance is not the same across the board.

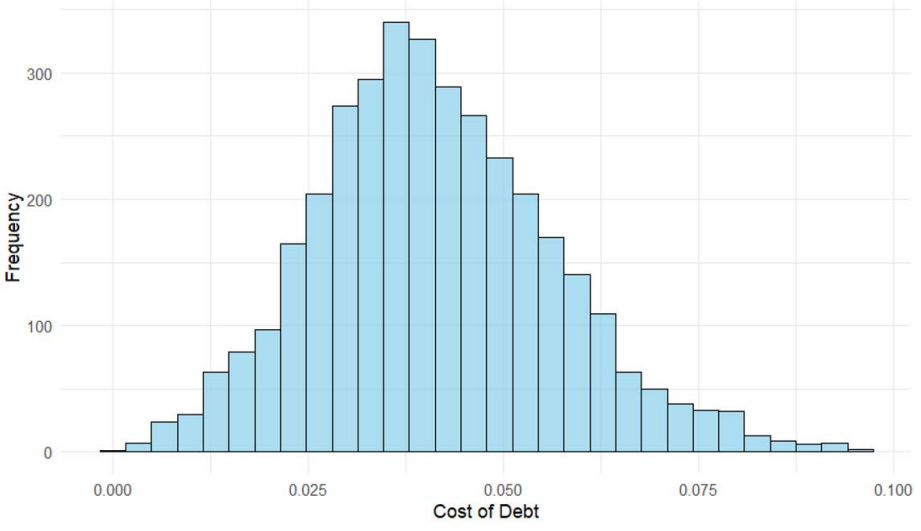

Fig. 1 Distribution of Cost of Debt

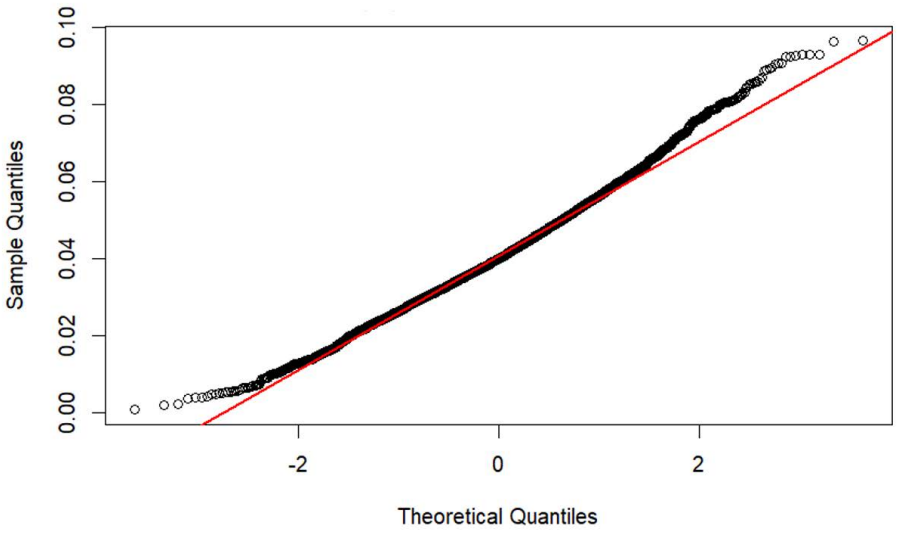

Fig. 2 Q-Q Plot of Cost of Debt

Fig. 1's histogram shows that the cost of debt is unimodal and slightly skewed to the right, but it is mostly centered around the mean. The Q–Q plot in Fig. 2 backs up this idea. It shows that most of the observations are very close to the theoretical quantiles, but the tails show that there are some outliers at very low and high debt costs. In general, the distribution of the dependent variable fits with the normality hypothesis for regression modeling.

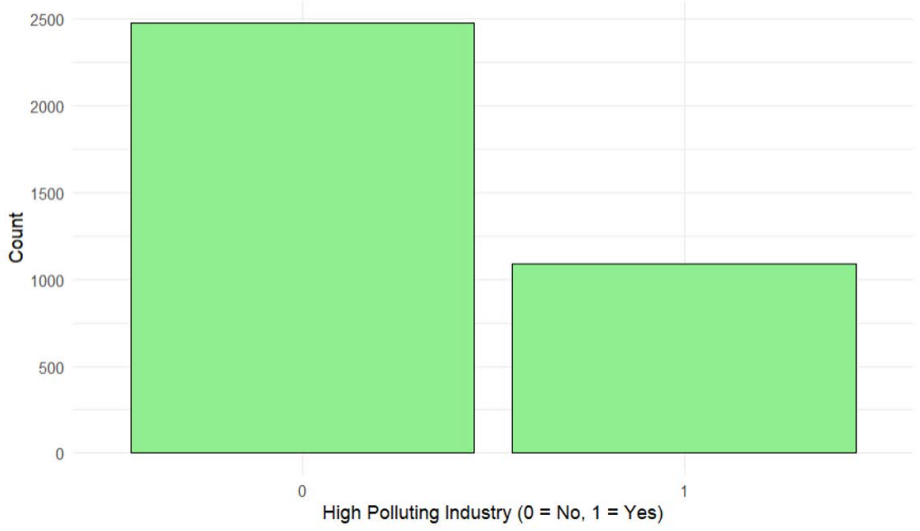

Fig. 3 Distribution of High-Polluting Firms

Lastly, Fig. 3 shows how businesses are spread out between industries that pollute a lot and those that don't. About 30% of the sample works in industries that pollute a lot, like mining, chemicals, and utilities. The other 70% works in industries that pollute less. This distribution gives us enough information to compare the two groups and see if environmental performance has different effects on debt costs based on the type of business.

5. Regression Results and Analysis

Table 2. Regression Results in Four Models

Variables	FE baseline	FE + interaction	FE High Polluting	FE Low Polluting
env_score	-0.001*	-0.001+	-0.000	-0.001*
	(0.000)	(0.000)	(0.000)	(0.000)

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log_assets	-0.008***	-0.008***	-0.010***	-0.007***
	(0.001)	(0.001)	(0.002)	(0.002)
leverage	-0.022**	-0.022**	-0.021*	-0.022*
	(0.008)	(0.008)	(0.010)	(0.009)
roa	-0.013+	-0.013+	-0.008	-0.015
	(0.007)	(0.007)	(0.007)	(0.010)
interaction		0.000		
		(0.001)		
Obs	3570	3570	1092	2478
R^2	0.086	0.086	0.102	0.082
RMSE	0.010	0.010	0.010	0.010
*Note: + p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001*				

Table 2 shows the results of the regression, which show how firms' environmental performance affects the cost of debt. The baseline fixed-effects model in column 2 indicates a statistically significant negative coefficient for environmental performance ($\beta = -0.001$, $p < 0.05$), implying that firms with superior environmental ratings incur reduced debt costs. The coefficient's absolute value is small, but its direction is in line with Hypothesis 1, which supports the idea that better environmental management practices lower firms' financing costs by lowering the risks that lenders see.

Column 3 incorporates an interaction term between environmental performance and the high-pollution industry indicator to rigorously evaluate Hypothesis 2. The coefficient on the interaction is statistically indistinguishable from zero ($\beta = 0.000$, $p>0.1$), which means that the effect of environmental performance on debt costs is not significantly different between high-polluting and low-polluting industries in the pooled specification. This outcome does not offer support for the second hypothesis, as the varying effect across industries remains unverified within the interactive framework. The main coefficient for environmental performance is still negative ($\beta = -0.001$, $p < 0.10$), which is in line with the baseline model.

To investigate this matter further, Column 4 and Column 5 compute distinct regressions for the high-polluting and low-polluting industry subsamples. In the high-polluting subsample of column 4, the coefficient for environmental performance is negligible and statistically insignificant ($\beta = -0.000$, $p>0.10$), indicating that in highly polluting industries like mining, chemicals, and utilities, environmental scores do not consistently lead to reduced debt costs after accounting for firm and year fixed effects. In the low-polluting subsample of column 5, however, the coefficient on environmental performance is negative and statistically significant ($\beta = -0.001$, $p < 0.05$). This finding suggests that the advantages of robust environmental performance in lowering debt costs may be more significant for companies in cleaner industries.

The control variables consistently perform across all specifications. In both subsamples, firm size is still a strong negative predictor of the cost of debt. This means that larger firms always pay less. Across all specifications, leverage stays negative and statistically significant. Profitability, on the other hand, is usually negative but not always significant. The R^2 values are between 0.082 and 0.102, which is normal for firm-level panel data where fixed effects take up most of the variance. The root mean squared error (RMSE) stays at about 0.01 across all models, which means that the fit of the models is consistent.

6. Conclusion

This research investigated the correlation between companies' environmental performance and their debt costs, focusing on the potential modulation of this relationship by industry pollution intensity. The analysis utilized a panel dataset of publicly traded U.S. firms from 2010 to 2023, employing fixed-effects regression models to account for unobserved heterogeneity among firms and across years. The results demonstrate that enhanced environmental performance correlates with reduced debt costs, thereby substantiating the notion that creditors incentivize sustainability-focused practices. However, this effect was not consistently more pronounced in high-polluting industries when analyzed through interaction models; conversely, subsample regressions indicated that the advantages of environmental performance might be more evident in low-pollution sectors.

These findings enhance the literature on environmental, social, and governance (ESG) factors by emphasizing the financial significance of environmental performance in debt markets. They also say that the link between sustain-

ability and financing is complicated and may depend on how lenders read environmental signals in different types of businesses. The findings underscore to managers that investing in environmental enhancements can provide concrete financial benefits, and this effect is particularly evident in industries with non-pollution.

Nonetheless, the study possesses certain limitations. The availability of data and the possibility of measurement error in ESG scores limit generalizability, and causal inference continues to be difficult even with fixed effects. Subsequent research may broaden by utilizing diverse identification methodologies or examining cross-national comparisons to evaluate the influence of institutional contexts on the nexus between environmental performance and capital costs.

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