

Debt Costs in the Carbon Transition: The Role of Carbon Disclosure, Environmental Performance, and Profitability

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Abstract

This research investigates how Carbon Emission Disclosure (CED), environmental performance, and profitability impact the borrowing costs of coal mining firms listed on the Indonesia Stock Exchange (IDX) between 2024 and 2025. Utilizing a quantitative explanatory design, the analysis draws on a balanced panel dataset comprising 21 firms, yielding 42 firm-year observations. The variables are operationalized as follows: CED via a disclosure index, environmental performance through the PROPER rating, profitability using Return on Assets (ROA), and borrowing costs derived from interest expenses divided by average interest-bearing liabilities. To determine the optimal estimator, the Chow, Hausman, and Lagrange Multiplier tests were applied, revealing that the Fixed Effect Model (FEM) is the most suitable. The empirical findings reveal that neither CED, environmental performance, nor profitability exert a statistically significant partial influence on borrowing costs at the 5% threshold. Furthermore, the Wald test confirms the absence of a simultaneous impact among these variables. Nevertheless, the global significance of the FEM highlights the crucial role of unobserved firm-specific traits in driving cost-of-debt variations. Ultimately, the results imply that lenders prioritize unique corporate attributes and loan agreement specifics over environmental disclosures and transient financial gains.

Keywords: *carbon emission disclosure; environmental performance; profitability; cost of debt; fixed effect model.*

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INTRODUCTION

Climate change and the transition toward a low-carbon economy have changed how companies are evaluated by investors, creditors, regulators, and other stakeholders. Environmental issues are increasingly considered part of corporate risk because they may create regulatory, transition, reputational, and financing risks. This issue is particularly relevant to coal companies because their core activities are closely associated with high carbon emissions. In Indonesia, coal remains economically important, with national production reaching approximately 836 million tons in 2024, while the government continues to pursue emission reduction and long-term energy transition targets (*Kementerian ESDM RI - Media Center - News Archives - Kinerja Sektor ESDM 2024: Lampui Target, Penuhi Kebutuhan Domestik, Dan Tingkatkan Ketahanan Energi*, 2025). These conditions create challenges for coal companies because creditors increasingly need to assess both financial and environmental risks (Ehlers et al., 2022; Gull et al., 2023). Creditors may consider potential environmental liabilities, regulatory sanctions, operational disruptions, and reputational risks that could affect future

cash flows. Therefore, environmental information may influence the risk premium required by creditors and ultimately affect the cost of debt.

The importance of sustainability information is also strengthened by sustainable finance regulations in Indonesia. Financial Services Authority Regulation No. 51/POJK.03/2017 requires financial service institutions, issuers, and public companies to implement sustainable finance principles and prepare sustainability reports (*POJK Nomor 51/POJK.03/2017*, 2017). However, greater disclosure does not necessarily mean that creditors directly use environmental information when determining debt prices. This creates an important empirical issue, particularly for companies operating in carbon-intensive industries. One factor that may affect the cost of debt is carbon emission disclosure. This disclosure provides information about greenhouse gas emissions, emission-reduction initiatives, climate-related risks, and carbon management strategies. From the perspective of information asymmetry, greater transparency may improve creditors' understanding of environmental risks and reduce uncertainty. Previous studies in Indonesia show that carbon emission disclosure has increasingly attracted research attention, although many studies still focus on its determinants rather than its financing consequences (Nilasakti et al., 2024; Nursulistyo et al., 2023).

From signaling theory, carbon emission disclosure can signal management quality and corporate preparedness in managing environmental risks. Companies with more comprehensive disclosure may provide creditors with greater confidence regarding their ability to manage carbon-related risks. However, for this signal to be credible, it must be supported by managerial integrity and transparent internal accountability systems, which transform superficial compliance into an ethical organizational culture (Mardiman, Taufik, et al., 2026). Nasih et al. (2024) found that higher carbon emission disclosure was associated with a lower cost of debt among Indonesian listed companies, suggesting that carbon transparency may reduce uncertainty perceived by creditors (Nasih et al., 2024). However, disclosure alone does not necessarily represent actual environmental practices. Therefore, environmental performance is also relevant. Environmental performance reflects how effectively a company manages its environmental impacts and complies with environmental standards. In Indonesia, environmental performance is commonly assessed through the PROPER rating system. Better environmental performance may reduce regulatory, reputational, and operational risks, which could lower perceived credit risk.

Empirical findings regarding environmental performance, however, remain inconsistent. Dewi (2025) found that environmental performance did not directly affect firm value, while carbon emission disclosure had a significant relationship with firm value. Similarly, Siagian et al. (2026) found that overall ESG performance was associated with lower debt costs, but the environmental dimension alone did not significantly affect the cost of debt. These findings indicate that creditors may not always consider environmental performance as a direct factor in debt pricing (Dewi, 2025; Siagian et al., 2026). Besides environmental factors, profitability is an important financial indicator in creditor assessments. Higher profitability generally reflects stronger cash-generation capacity and a greater ability to meet interest and principal payments. This condition can reduce default risk and potentially lower the cost of debt. However, profitability may not fully offset environmental risks, especially in coal companies that face commodity price volatility, regulatory pressures, and energy-transition risks.

Carbon emission disclosure, environmental performance, and profitability therefore provide different but complementary information. Carbon emission disclosure represents environmental transparency, environmental performance reflects actual environmental outcomes, and profitability represents financial capacity. Examining these variables simultaneously can provide a more comprehensive understanding of how creditors assess firms operating in carbon-intensive industries. Previous studies have reported inconsistent findings. Nasih et al. (2024) found that carbon emission disclosure reduced the cost of debt,

whereas Siagian et al. (2026) showed that the environmental dimension of ESG did not independently influence debt costs. These differences indicate that creditor responses may depend on industry characteristics, environmental exposure, information quality, and regulatory conditions.

More specifically, Maulana et al. (2026) examined coal sub-sector companies listed on the Indonesia Stock Exchange during 2024–2025 and found that carbon emission disclosure, environmental performance, and profitability did not significantly affect the cost of debt, either individually or simultaneously. These findings differ from studies showing that carbon transparency and broader sustainability practices can reduce financing costs (Nasih et al., 2024; Siagian et al., 2026). This inconsistency provides a basis for re-examining whether creditors incorporate environmental and financial information into the pricing of debt in Indonesia's coal industry.

This study is theoretically supported by signaling theory and stakeholder theory. Signaling theory explains that companies can reduce information asymmetry by providing credible information to external parties (López-Santamaría et al., 2021). Carbon emission disclosure may signal a company's preparedness in managing environmental risks, while environmental performance provides evidence of actual environmental outcomes (Nasih et al., 2024). Stakeholder theory further explains that companies need to respond to the interests of important stakeholders, including creditors, who provide essential financial resources and actively monitor corporate risk orientations (Keswani et al., 2021). Grounded in these premises, this research seeks to analyze how profitability, environmental performance, and carbon reporting influence the borrowing costs of coal mining firms listed on the IDX from 2024 to 2025. Specifically, this study investigates the individual and simultaneous effects of these three variables on corporate debt financing costs. This study is expected to contribute to the literature on environmental accounting and corporate financing by providing sector-specific evidence from a carbon-intensive industry in an emerging economy. The findings may also help companies understand whether environmental transparency and performance provide financing benefits, assist creditors in evaluating environmental and financial risks, and support regulators in assessing the effectiveness of sustainable finance practices in Indonesia.

METHODOLOGY

This research utilizes a quantitative explanatory approach leveraging balanced panel data to investigate how Carbon Emission Disclosure, Environmental Performance, and Profitability affect the Borrowing Costs of coal mining enterprises listed on the IDX between 2024 and 2025. The unit of analysis is the firm-year. Panel data are used because they combine cross-sectional observations across companies with time-series observations across reporting periods, allowing differences between firms and changes over time to be considered within a single estimation framework.

The population comprises coal subsector companies classified under IDX-IC A121 and listed on the Indonesia Stock Exchange. The sample is selected using purposive sampling with the following criteria: the company is listed throughout the 2024–2025 observation period; publishes annual reports and/or sustainability reports for both years; has environmental-performance information available through the PROPER program; and provides the financial information required to calculate profitability and the cost of debt, including net income, total assets, interest expense, and interest-bearing debt. The absence of a carbon-disclosure item does not by itself exclude an observation because non-disclosure is coded as zero in the disclosure index.

Consistent with the dataset used for this research setting, the final balanced panel consists of 21 companies, producing 42 firm-year observations.

The study uses secondary data collected through documentation. Annual reports, audited financial statements, and sustainability reports are obtained from the Indonesia Stock Exchange and the official websites of the sample companies, while environmental-performance data are obtained from the Corporate Performance Rating Program in Environmental Management (PROPER) published by the Ministry of Environment. A standardized coding sheet is used to record the information required for each variable so that the measurement procedure is applied consistently across firms and years. Carbon Emission Disclosure (CED) is measured using an 18-item carbon-emission disclosure checklist, following the dichotomous scoring approach used by Nasih et al. (2024). Each item receives a score of 1 when the relevant information is disclosed and 0 when it is not disclosed. The disclosure index ranges from 0 to 1 and is calculated as follows:

$$CEDit = \sum Xijt / 18 \quad (1)$$

Where CEDit represents the carbon emission disclosure index of company *i* in year *t*, and *Xijt* represents the score assigned to disclosure item *j*. Environmental Performance (EP) is measured using the PROPER rating and converted into an ordinal numerical score: Gold = 5, Green = 4, Blue = 3, Red = 2, and Black = 1. Profitability is proxied by Return on Assets (ROA), which reflects the company's ability to generate earnings from its asset base:

$$ROAit = \text{Net Income}_{it} / \text{Total Assets}_{it} \quad (2)$$

The dependent variable, Cost of Debt (COD), represents the effective financing cost borne by a company on interest-bearing debt. Following the measurement used in carbon-disclosure and debt-cost research, COD is calculated by dividing interest expense by average interest-bearing debt. Average interest-bearing debt is the mean of beginning-of-year and end-of-year interest-bearing debt:

$$CODit = \text{Interest Expense}_{it} / \text{Average Interest-Bearing Debt}_{it} \quad (3)$$

Data analysis begins with descriptive statistics to summarize the distribution of each variable. The main hypotheses are tested using panel-data regression. The empirical model is specified as follows:

$$CODit = \alpha + \beta_1 CEDit + \beta_2 EPit + \beta_3 ROAit + \mu_i + \varepsilon_{it} \quad (4)$$

Where α is the constant; β_1 – β_3 are the regression coefficients; μ_i captures unobserved firm-specific effects; and ε_{it} is the idiosyncratic error term. The appropriate panel estimator is determined by comparing the Common Effect Model, Fixed Effect Model, and Random Effect Model using the Chow test, Breusch–Pagan Lagrange Multiplier test, and Hausman test (Baltagi, 2021). Multicollinearity is evaluated using the correlation matrix and/or Variance Inflation Factor, while heteroskedasticity is assessed on the selected model. When the error structure indicates heteroskedasticity or other non-spherical disturbances, robust standard errors are applied so that statistical inference remains reliable. Hypothesis testing is

conducted at a 5% significance level. The partial effect of each independent variable is evaluated from the coefficient significance test, while the simultaneous effect of Carbon Emission Disclosure, Environmental Performance, and Profitability on the Cost of Debt is evaluated using the model's joint significance test. The coefficient of determination is reported to assess the explanatory power of the model. All panel-data estimations are performed using EViews 13.

RESULTS AND DISCUSSION

The empirical analysis uses a balanced panel of 42 firm-year observations from 21 coal subsector companies during 2024–2025. Three panel estimators were initially examined: the Common Effect Model (CEM), the cross-section Fixed Effect Model (FEM), and the Random Effect Model (REM). The comparison is necessary because the choice of estimator determines whether unobserved firm-specific characteristics are treated as common, fixed, or random components of the regression model.

Panel Data Model Selection

The model-selection results indicate that firm-specific heterogeneity cannot be ignored. The Chow test comparing the pooled specification with the cross-section fixed-effects specification produces an F-statistic of 6.4454 with a probability of approximately 0.0001. Therefore, the null hypothesis in favor of the Common Effect Model is rejected. The Breusch–Pagan Lagrange Multiplier test also rejects the pooled model in favor of a model containing cross-section effects (statistic 6.267043; probability 0.0123). Finally, the Hausman test comparing the fixed and random specifications yields a Chi-square statistic of 10.4290 with a probability of approximately 0.0153. Because this probability is below the 5% significance level, the Fixed Effect Model is preferred to the Random Effect Model. Accordingly, the cross-section FEM is used as the principal model for hypothesis interpretation.

Table 1. Panel Data Model Selection Results

Test	Models Compared	Statistic	Prob.	Decision
Chow test	CEM vs FEM	F = 6.4454	0.0001	FEM
Hausman test	FEM vs REM	Chi-square = 10.4290	0.0153	FEM
Breusch–Pagan LM	CEM vs REM	6.267043	0.0123	REM over CEM

Source: EViews 13 output and calculations based on the same 42-observation panel dataset (2026).

The screenshots also show a two-way fixed-effects specification containing both cross-section and period dummy variables. In that specification, the CED coefficient is 0.048913 with a probability of 0.0694, while PROPER and ROA remain statistically insignificant. A supplementary redundancy check for the additional period effect yields an F-statistic of approximately 2.3675 ($p = 0.1423$), indicating that the year-specific fixed effect is not required at the 5% level. This supports the use of the more parsimonious cross-section FEM.

Fixed Effect Model Estimation Results

Table 2 presents the cross-section FEM used for the main interpretation. CED has a positive coefficient of 0.045204 with a probability value of 0.0998. PROPER has a coefficient of 0.007329 with a probability value of 0.2495, while ROA has a coefficient of 0.018868 with a probability value of 0.1728. At the predetermined 5% significance level, none of the three explanatory variables has a statistically significant partial effect on the cost of debt.

Table 2. Cross-Section Fixed Effect Model Estimation Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.002494	0.032556	0.076603	0.9398
CED	0.045204	0.026054	1.735040	0.0998
PROPER	0.007329	0.006159	1.190041	0.2495
ROA	0.018868	0.013292	1.419515	0.1728

Source: EViews 13 output, processed by the authors (2026).

The estimated slope component of the fixed-effects equation can be written as follows:

$$COD = 0.002494 + 0.045204 \text{ CED} + 0.007329 \text{ PROPER} + 0.018868 \text{ ROA} + \text{Firm Fixed Effects}$$

The cross-section FEM produces an R-squared value of 0.897992 and an adjusted R-squared value of 0.767649. These values should be interpreted as the explanatory power of the complete fixed-effects specification, which includes the observed explanatory variables together with company-specific dummy effects. Therefore, the high R-squared should not be attributed solely to CED, PROPER, and ROA. The overall model F-statistic is 6.889438 with a probability of 0.000055, indicating that the complete fixed-effects specification is statistically significant. Because the overall F-statistic of a fixed-effects regression also reflects the contribution of firm dummy variables, an additional joint test of only the three slope coefficients is necessary for the simultaneous research hypothesis. The slope-only Wald test produces an F-statistic of approximately 1.6026 with a probability of 0.2238. Accordingly, CED, environmental performance, and profitability do not jointly have a statistically significant effect on cost of debt at the 5% level. The contrast between the significant overall FEM and the insignificant slope-only joint test indicates that company-specific characteristics account for an important part of the observed variation in borrowing costs.

Effect of Carbon Emission Disclosure on Cost of Debt

CED has a coefficient of 0.045204 and a probability value of 0.0998 in the selected fixed-effects model. Since the probability value is greater than 0.05, carbon emission disclosure does not have a statistically significant effect on cost of debt at the significance level established in the methodology. The positive coefficient indicates a positive within-firm direction, but this relationship is not sufficiently strong to support the hypothesis. The probability value is close to the 10% level; therefore, it may be described as marginal evidence only in an exploratory sense and should not be treated as significant under the study's 5% decision rule. An important feature of the results is the difference between the pooled and fixed-effects estimates. Under CEM, CED has a negative coefficient of -0.050743 with a probability of 0.0126, whereas the selected FEM produces a positive coefficient of 0.045204 with a probability of 0.0998. The reversal in sign and significance suggests that the negative association observed in pooled data is influenced by persistent differences across companies. Once time-invariant firm characteristics are controlled through fixed effects, changes in carbon disclosure within the same company are not associated with statistically significant changes in debt cost at the 5% level. This finding demonstrates why controlling for unobserved heterogeneity is important in this sample.

From a signaling-theory perspective, carbon disclosure is expected to reduce information asymmetry by conveying management preparedness and transparency regarding climate-related risks. The insignificant fixed-effects result suggests that this signal may not yet be sufficiently influential in creditor pricing decisions in the coal subsector. Creditors may place greater weight on contractual and financial risk indicators, while carbon information functions as complementary rather than decisive information. The result differs from Nasih et al. (2024), who found that higher carbon emission disclosure was associated with lower debt costs in a broader Indonesian listed-company setting, but it is consistent with the sector-specific result reported.

Effect of Environmental Performance on Cost of Debt

Environmental performance, measured using the PROPER score, has a coefficient of 0.007329 and a probability value of 0.2495. The probability value is greater than 0.05, indicating that environmental performance does not have a statistically significant effect on cost of debt. Thus, differences in environmental performance within the sampled companies were not followed by statistically detectable changes in borrowing costs during 2024–2025. Although stronger PROPER performance can indicate better environmental compliance and risk management, creditors may not translate the rating directly into interest pricing. Environmental performance may remain relevant to regulatory, operational, and reputational risk without producing an immediate financing benefit. This interpretation is consistent with Siagian et al. (2026), who reported that the environmental dimension of ESG did not independently affect debt costs, and it is also compatible with Dewi (2025), who found no direct effect of environmental performance on firm value. From a stakeholder perspective, the result indicates that environmental performance may serve accountability and legitimacy functions even when it does not directly alter the cost of borrowed funds (Dewi, 2025; Siagian et al., 2026). This aligns with broader organizational evidence that formal management control systems do not directly improve financial outcomes without a mediating information system (Hakiki et al., 2025; Mardiman, Sobandi, et al., 2026). Creditors may view current environmental disclosures as mere administrative compliance rather than operational reality. Evidence from other sectors suggests that genuine environmental accountability requires real-time digital monitoring and an embedded organizational culture to influence stakeholder decisions (Mardiman, Maulana Suwanta, et al., 2026).

Effect of Profitability on Cost of Debt

Profitability, proxied by ROA, has a coefficient of 0.018868 with a probability value of 0.1728. Because the probability exceeds 0.05, profitability does not have a statistically significant effect on cost of debt in the selected model. The result implies that changes in accounting profitability within the sampled coal companies were not sufficient to explain changes in borrowing costs during the observation period. Creditors generally consider profitability as an indicator of debt-servicing capacity. Nevertheless, lending decisions also incorporate leverage, liquidity, collateral, debt maturity, credit quality, contractual terms, cash-flow stability, and environmental risk premiums (Pizzutilo et al., 2020). In a commodity-based industry, reported profitability can fluctuate considerably with coal prices and operating conditions, reducing its ability to function as a stand-alone determinant of debt pricing over a two-year period. The result is consistent with Maulana et al. (2026), who likewise found that profitability did not significantly affect the cost of debt in coal subsector companies.

Simultaneous Effect and the Role of Firm-Specific Heterogeneity

The joint Wald test of CED, PROPER, and ROA produces a probability of approximately 0.2238, which is greater than 0.05. Therefore, the three explanatory variables are not jointly significant when the test is restricted to their slope coefficients. At the same time, the complete fixed-effects model is significant at the 5% level ($\text{Prob}(\text{F-statistic}) = 0.000055$). These two results are not contradictory: the overall model includes cross-section fixed effects, while the slope-only test isolates the three research variables. The evidence therefore indicates that unobserved company-specific factors play a substantial role in explaining differences in cost of debt. Taken together, the findings qualify the expectation derived from signaling theory. Greater carbon transparency, better environmental performance, and higher profitability do not automatically translate into a measurable reduction in debt costs once persistent firm characteristics are controlled. For creditors in the coal subsector, company-specific features that are not fully represented by the three variables may be more decisive in debt pricing. Future research can investigate this possibility by extending the observation period and incorporating financial-risk and debt-contract variables such as leverage, liquidity, firm size, collateral, maturity structure, and credit quality.

Table 3. Summary of Hypothesis Testing

Relationship	Test Result	5% Decision	Conclusion
CED $\rightarrow$ COD	$p = 0.0998$	Not significant	Not supported
PROPER $\rightarrow$ COD	$p = 0.2495$	Not significant	Not supported
ROA $\rightarrow$ COD	$p = 0.1728$	Not significant	Not supported
CED, PROPER, ROA $\rightarrow$ COD	Wald $p = 0.2238$	Not significant	Not supported

Source: EViews 13 output and calculations based on the same panel dataset (2026).

CONCLUSION

This research investigated how Profitability, Environmental Performance, and Carbon Emission Disclosure influence the Borrowing Costs of 21 coal mining firms listed on the IDX between 2024 and 2025. Model selection indicates that the cross-section Fixed Effect Model is the most appropriate specification, showing that persistent firm-specific characteristics need to be controlled when explaining differences in corporate debt costs. At the 5% significance level, Carbon Emission Disclosure, Environmental Performance measured by PROPER, and Profitability measured by ROA do not individually have significant effects on the Cost of Debt. The joint Wald test also shows that the three explanatory variables are not simultaneously significant when their slope coefficients are tested together. The findings further show that the overall fixed-effects specification is statistically significant, indicating that company-specific heterogeneity contributes materially to the variation in debt costs. Carbon disclosure displays only marginal evidence at the 10% level and should not be interpreted as significant under the study's 5% criterion. Overall, the results suggest that environmental transparency, environmental performance, and short-term profitability were not the primary determinants of borrowing costs in the sampled coal companies during the two-year observation period. Creditors may rely more strongly on other firm-specific and debt-contract characteristics. Extending the observation period and incorporating leverage, liquidity, firm size, credit quality, collateral, and debt maturity may provide a more comprehensive explanation of cost-of-debt variation in future research.

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