



The Influence of Carbon Risk on Debt Structure: An Empirical Study on Companies Listed on in the Indonesian Stock Exchange 2024 Period

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Abstract. This study examines the influence of carbon risk on debt structure among companies listed on the Indonesia Stock Exchange (IDX) during 2024. Carbon risk is measured using the natural logarithm of Scope 1 and Scope 2 greenhouse gas emissions, while debt structure is proxied by the proportion of bank debt to total debt. Firm size and leverage are included as control variables. Using a quantitative approach, this study analyzes secondary data from 337 companies selected through purposive sampling. Multiple linear regression with the Ordinary Least Squares (OLS) method is employed using IBM SPSS. The results indicate that carbon risk has no significant influence on debt structure, suggesting that firms with higher carbon emissions do not necessarily rely less on bank debt. The findings imply that Indonesian banks continue to prioritize traditional credit assessment factors, such as financial performance and repayment capacity, rather than carbon-related risks in lending decisions. This study contributes to the sustainable finance literature by providing empirical evidence from an emerging market and offers insights for regulators, financial institutions, and future research on the integration of climate-related risks into corporate financing decisions.

Keywords: Bank Debt; Carbon Risk; Debt Structure; Indonesia; Sustainable Finance.

1. INTRODUCTION

Climate change has become one of the most significant global challenges, increasing the importance of carbon risk in corporate decision-making. Carbon risk refers to a firm's exposure to financial and operational consequences arising from greenhouse gas emissions, including stricter environmental regulations, transition costs, reputational concerns, and changing stakeholder expectations. As governments continue to strengthen climate policies and sustainable finance initiatives, environmental performance has become an increasingly important consideration for investors and creditors when evaluating corporate risk.

Previous studies have shown that carbon risk has important financial implications. Firms with higher carbon emissions tend to experience lower firm value Matsumura et al. (2014), higher cost of debt Jung et al. (2018), and higher cost of equity (Yan et al., 2025). More recently, Nasr et al. (2025) found that firms with greater carbon risk rely less on bank debt because banks impose stricter monitoring and lending requirements on environmentally risky borrowers. These findings suggest that climate-related risks may influence not only the cost of financing but also firms' debt structure.

The relationship between carbon risk and debt structure is particularly relevant in Indonesia. As one of the world's largest carbon emitters, Indonesia has strengthened its commitment to sustainable finance through regulations such as POJK No. 51/POJK.03/2017 and the Climate Risk Management and Scenario Analysis (CRMS) guideline issued by the Financial Services

Authority (OJK). These policies encourage financial institutions to incorporate climate-related risks into lending decisions, indicating that carbon risk may increasingly influence corporate access to bank financing.

Despite the growing literature on climate finance, empirical evidence examining the relationship between carbon risk and debt structure remains limited, particularly in emerging markets such as Indonesia. Most previous studies have been conducted in developed countries where sustainable finance regulations and financial markets are more mature. Consequently, it remains unclear whether carbon risk influences financing decisions under Indonesia's institutional and regulatory environment.

This study aims to examine the influence of carbon risk on debt structure among companies listed on the Indonesia Stock Exchange during 2024. Carbon risk is measured using the natural logarithm of Scope 1 and Scope 2 greenhouse gas emissions, while debt structure is measured by the proportion of bank debt to total debt. By providing evidence from an emerging market, this study contributes to the growing literature on sustainable finance and offers insights into whether climate-related risks have been incorporated into corporate lending decisions in Indonesia.

2. LITERATURE REVIEW

Agency Theory

Agency Theory explains the contractual relationship between shareholders (principals) and managers (agents), in which managers generally possess more information regarding the firm's operations and risk exposure than external stakeholders, resulting in information asymmetry (Jensen & Meckling, 1976). According to Healy & Palepu, (2001), this information asymmetry makes it difficult for investors and creditors to accurately assess a firm's financial condition and future prospects. Consequently, corporate disclosure plays an important role in reducing uncertainty by improving transparency.

In the context of carbon risk, environmental disclosure enables investors and creditors to better evaluate firms' climate-related risks. Steindl et al. (2024) argue that carbon disclosure improves the transparency and comparability of environmental information, thereby reducing information asymmetry. However, information asymmetry may persist because firms do not always fully disclose carbon-related risks (Islam et al., 2025). Bose et al. (2025) further demonstrate that firms with higher carbon risk are more likely to experience stock price crash risk, indicating that carbon-related uncertainty intensifies agency conflicts.

From the perspective of debt financing, agency conflicts become more pronounced because creditors seek to protect themselves against risky corporate behavior. Myers (1977) argues that risky debt encourages creditors to impose stricter monitoring and contractual protections. Consequently, firms with greater carbon risk may reduce their reliance on bank financing to avoid intensive monitoring, consistent with the findings of (Nasr et al., 2025).

Delegated Monitoring Theory

Delegated Monitoring Theory explains that banks act as specialized financial intermediaries that monitor borrowers on behalf of dispersed investors (Diamond, 1984). Rather than monitoring borrowers individually, investors delegate this responsibility to banks, allowing monitoring activities to be conducted more efficiently while reducing information costs and moral hazard. Banks possess specialized expertise, access to private information, and long-term lending relationships that enable them to supervise borrowers more effectively than public debt investors (Brealey et al., 2019; Diamond, 1984).

In this study, Delegated Monitoring Theory suggests that firms with higher carbon risk are likely to face more intensive monitoring because climate-related risks increase uncertainty regarding future financial performance and environmental liabilities. Since bank loans generally involve stricter loan covenants and continuous monitoring, firms with higher carbon risk may prefer financing sources that require less monitoring, thereby reducing their reliance on bank debt (Nasr et al., 2025).

Stakeholder Theory

Stakeholder Theory argues that firms operate within a network of stakeholders whose interests extend beyond shareholders alone (Freeman & McVea, 2008). Companies are therefore expected to balance economic objectives with social and environmental responsibilities in order to maintain long-term relationships with investors, creditors, regulators, customers, employees, and society (Awa et al., 2024).

From the perspective of this study, Stakeholder Theory explains how environmental expectations influence bank lending decisions. Banks themselves are accountable to multiple stakeholders and therefore face increasing pressure to incorporate climate-related risks into their lending activities. Previous studies show that environmentally risky lending may lead to deposit withdrawals and greater instability in bank funding (Homanen, 2018; Houston et al., 2021). Consequently, banks may offer more favorable financing terms to environmentally responsible firms while imposing stricter lending requirements on firms with higher carbon emissions (Nandy & Lodh, 2012; Nasr et al., 2025).

Carbon Risk

Carbon risk refers to the non-financial risk arising from a firm's exposure to climate change and the transition toward a low-carbon economy. Firms with higher carbon emissions are generally more vulnerable to physical climate events, stricter environmental regulations, and increasing stakeholder expectations. Consequently, carbon-intensive firms may face higher compliance costs, operational disruptions, and reputational pressures, all of which can adversely affect their operational and financial performance (Cumming et al., 2025; Bose et al., 2025). As environmental issues become increasingly important to investors, creditors, and regulators, carbon risk has become a key consideration in corporate financing and investment decisions.

Previous studies have measured carbon risk using various proxies, including carbon emissions, carbon intensity, carbon disclosure, and environmental performance indicators. Following Ben-Nasr et al. (2025), this study measures carbon risk using the natural logarithm of total Scope 1 and Scope 2 greenhouse gas emissions disclosed in firms' sustainability reports. Scope 1 represents direct emissions generated from sources owned or controlled by the firm, while Scope 2 represents indirect emissions associated with purchased electricity, steam, heating, or cooling. The logarithmic transformation is applied to reduce data skewness while preserving differences in firms' carbon emission levels.

Debt Structure

Debt structure refers to the composition of debt instruments used by a firm to finance its operations and investments, including bank loans, corporate bonds, leases, and other interest-bearing liabilities. The choice of debt instruments reflects firms' efforts to balance financing costs, financial flexibility, and risk management. Because different debt instruments involve different levels of monitoring and contractual arrangements, debt structure is influenced by factors such as information asymmetry, agency conflicts, and refinancing risk (Colla et al., 2020).

Following Nasr et al. (2025), this study measures debt structure using the bank debt ratio, calculated as the proportion of bank debt to total corporate debt. This proxy captures the extent to which firms rely on bank financing relative to other debt instruments. Since bank loans generally involve closer lender–borrower relationships and more intensive monitoring than public debt, the bank debt ratio provides an appropriate measure for examining whether firms' reliance on bank financing changes in response to carbon risk.

Hypothesis Development

Environmental risks have increasingly translated into measurable economic consequences, affecting firms' financing decisions and access to external capital (Chava, 2014). More recently, financial institutions have begun incorporating climate-related risks into their lending decisions through stricter environmental assessments and higher loan pricing for environmentally risky borrowers, reflecting the growing importance of climate risk in credit markets (Dong et al., 2025). From the perspective of Agency Theory, carbon risk increases information asymmetry because managers possess superior information regarding firms' environmental exposure, encouraging creditors to strengthen their monitoring of borrowers (Islam et al., 2025; Bose et al., 2025). Consistent with Delegated Monitoring Theory, banks possess superior monitoring capabilities and may impose stricter lending conditions on firms with higher carbon risk, leading these firms to reduce their reliance on bank financing (Diamond, 1984; Nasr et al., 2025).

Stakeholder Theory further suggests that banks increasingly incorporate environmental considerations into lending decisions because they are accountable to regulators, investors, depositors, and the public. This argument is particularly relevant in Indonesia following the implementation of POJK No. 51/POJK.03/2017, the Climate Risk Management and Scenario Analysis (CRMS) guideline, and the Indonesia Green Taxonomy, which encourage the integration of climate-related risks into banking activities. Consistent with these theoretical arguments, Nasr et al. (2025) find that firms with higher carbon emissions maintain a lower proportion of bank debt in their debt structure. Therefore, this study proposes the following hypothesis:

H1: Bank debt reliance is negatively related to carbon risk.

3. RESEARCH METHOD

Population and Sample

The population of this study consists of all companies listed on the Indonesian Stock Exchange (IDX) during the 2024 reporting period. A purposive sampling method was employed to select the research sample, as this technique enables researchers to identify observations that meet specific criteria relevant to the research objectives (Salkind, 2017). To ensure the suitability of the data for statistical analysis, several sampling criteria were established. First, the company must have been listed on the Indonesian Stock Exchange (IDX) in 2024. Second, the company must disclose its Scope 1 and Scope 2 carbon emissions in its sustainability report or integrated annual report for the 2024 period. Third, the company must disclose

information regarding both bank debt and total debt in its 2024 financial statements. Based on these criteria, the initial population consisted of 947 companies listed on the IDX in 2024. After excluding 610 companies that did not satisfy one or more of the sampling requirements, a final sample of 337 companies was obtained for empirical analysis.

Variables and Measurement

This study employs one dependent variable, one independent variable, and two control variables. The dependent variable is Debt Structure (Y), measured by Bank Debt Reliance, calculated as the ratio of total bank debt to total debt. The independent variable is Carbon Risk (X1), measured using the natural logarithm of total Scope 1 and Scope 2 carbon emissions, following Ben-Nasr et al. (2025). To control for firm-specific characteristics, Firm Size (X2) is measured as the natural logarithm of total assets, while Leverage (X3) is measured as the ratio of total debt to total assets. These control variables are included because previous studies suggest that firm size and leverage may influence firms' financing decisions and debt structure.

4. RESULTS AND DISCUSSION

Table 1. Descriptive Statistical Analysis.

	Bank Debt (Y)	Carbon risk (X1)	Firm Size (X2)	Leverage (X3)
(N) Valid	337	337	337	337
(N) Missing	0	0	0	0
Mean	0.3657	9.6073	24.3451	0.5212
Std. Deviation	0.25706	3.57778	5.06658	0.3831
Minimum	0	1.88	12.34	0.02
Maximum	0.98	18.79	32.49	3.82

The table above is presenting the descriptive statistics for all variables based on 337 firm observations. Carbon Risk (X1), measured as the natural logarithm of Scope 1 and Scope 2 carbon emissions, has a minimum value of 1.88, a maximum value of 18.79, a mean of 9.6073, and a standard deviation of 3.57778, indicating variation in firms' carbon emissions. Debt Structure (Y), measured as the ratio of bank debt to total debt, ranges from 0.00 to 0.98, with a mean of 0.3657 and a standard deviation of 0.25706, suggesting that bank debt accounts for an average of 36.57% of total corporate debt. Firm Size (X2), measured as the natural logarithm of total assets, has values ranging from 12.34 to 32.49, with a mean of 24.3451 and a standard deviation of 5.06658. Meanwhile, Leverage (X3), measured as the ratio of total debt to total assets, ranges from 0.02 to 3.82, with a mean of 0.5212 and a standard deviation of 0.38310, indicating that, on average, 52.12% of firms' assets are financed through debt.

Table 2. Coefficient of Determination Test.

Indicator	Value
R	0.118
R Square (R^2)	0.014
Adjusted R Square	0.005
Std. Error of the Estimate	0.25642

The coefficient of determination (R^2) is 0.014, indicating that Carbon Risk (X1), Firm Size (X2), and Leverage (X3) jointly explain 1.4% of the variation in Debt Structure (Y), while the remaining 98.6% is explained by factors outside the model. The adjusted R^2 of 0.005 suggests that, after accounting for the number of predictors and sample size, the model explains only 0.5% of the variation in the dependent variable, indicating relatively low explanatory power. Furthermore, the correlation coefficient (R) of 0.118 reflects a very weak relationship between the independent variables and Debt Structure, while the standard error of the estimate (0.25642) indicates the average deviation between the observed and predicted values.

Table 3. F-Test.

Indicator	Value
F Statistic	1.567
Significance	0.197

The simultaneous significance test (F-test) was conducted to assess whether Carbon Risk (X1), Firm Size (X2), and Leverage (X3) jointly affect Debt Structure (Y). The regression model produced an F-statistic of 1.567 with a significance value of 0.197, which exceeds the 0.05 significance level (Gujarati, 2009). Therefore, the model is not statistically significant, indicating that Carbon Risk, Firm Size, and Leverage do not jointly explain the variation in Debt Structure. This finding is consistent with the low coefficient of determination ($R^2 = 0.014$), suggesting that the model explains only 1.4% of the variation in Debt Structure, while the remaining 98.6% is attributable to other factors not included in the study.

Table 4. T-Test.

Variables	Coefficient (B)	t-Statistic	Sig.
Carbon Risk (X1)	0.002	0.565	0.573
Firm Size (X2)	0.006	2.121	0.035
Leverage (X3)	0.012	0.321	0.749

The partial significance test (t-test) was conducted to examine the individual effects of Carbon Risk (X1), Firm Size (X2), and Leverage (X3) on Debt Structure (Y). The results show that Carbon Risk has a positive but insignificant effect on Debt Structure ($\beta = 0.002$; $t = 0.565$;

$p = 0.573$), indicating that the proposed hypothesis of a negative relationship between Carbon Risk and Bank Debt Reliance is not supported. Firm Size has a positive and statistically significant effect on Debt Structure ($\beta = 0.006$; $t = 2.121$; $p = 0.035$), suggesting that larger firms tend to rely more on bank debt. In contrast, Leverage has a negative but insignificant effect on Debt Structure ($\beta = -0.012$; $t = -0.321$; $p = 0.749$), implying that the proportion of total debt to total assets does not significantly influence firms' reliance on bank debt.

Discussion

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The results do not support H1, which proposes that Bank Debt Reliance is negatively related to Carbon Risk. Although the estimated coefficient for Carbon Risk is positive ($\beta = 0.002$), the relationship is not statistically significant ($p = 0.573$), indicating that Carbon Risk does not influence firms' reliance on bank debt. The absence of a statistically significant relationship suggests that Carbon Risk may not yet be an important consideration in corporate financing decisions among Indonesian listed companies. Several factors may explain this finding. First, Indonesian banks may continue to prioritize conventional lending criteria, such as financial performance, repayment capacity, collateral, liquidity, and overall creditworthiness, rather than carbon emissions or environmental performance when evaluating corporate borrowers. Second, although Indonesia has introduced various sustainable finance initiatives through the Financial Services Authority (OJK), the integration of Carbon Risk into banks' credit assessment practices may still be at an early stage. Consequently, Carbon Risk has not yet become a significant determinant of corporate debt structure. These findings differ from those of Nasr et al. (2025), who documented a significant negative relationship between Carbon Risk and Bank Debt Reliance. This discrepancy may be attributed to differences in institutional and regulatory environments, as previous studies were conducted in countries with more mature sustainable finance frameworks, whereas Indonesian banks may still place greater emphasis on traditional financial considerations than climate-related risks.

5. CONCLUSION

This study examines the influence of Carbon Risk on Debt Structure, measured by Bank Debt Reliance, among companies listed on the Indonesia Stock Exchange (IDX) in 2024. The empirical results indicate that Carbon Risk does not have a statistically significant effect on Debt Structure, despite exhibiting a positive regression coefficient. Accordingly, the findings do not support the hypothesis that firms with higher Carbon Risk rely less on bank debt

financing, suggesting that Carbon Risk has not yet become a significant determinant of corporate debt structure among Indonesian listed companies.

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