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Is the Cost of Corporate Debt Affected by the Volume and Intensity of Carbon Emissions? Empirical Evidence from Indonesian Companies

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ABSTRACT
This study aims to examine the impact of carbon risk on the debt costs of non-financial companies listed on the Indonesia Stock Exchange (idx) from 2017 to 2023. Carbon risk is proxied by carbon emission volume and carbon emission intensity, which are considered more closely aligned with the government's goal of achieving net-zero emissions by 2060. The hypothesis is tested using fixed-effects regression on a 1,023-unbalanced panel dataset. The results show that before the implementation of the Financial Services Authority Regulation (POJK) No. 51 of 2017, carbon risk had a significant negative impact on corporate debt costs. Following the implementation of the regulation, the negative effect of carbon risk on the cost of debt weakened and became statistically insignificant positive direction. This indicates that creditors have begun to internalize the carbon risk in their assessment of corporate borrowing costs.

INTRODUCTION

The Indonesian government is committed to achieving carbon neutrality (net zero emission) by 2060 (menlhk.go.id). As part of this effort, the government issued Financial Services Authority Regulation No. 51/POJK.03/2017 which requires companies to prepare sustainability reports, including reporting related to carbon emissions management. According to Zhou *et al*. (2024), climate and environmental policies implemented by the government are designed to influence the scale, speed and character of the transformation towards renewable energy. Pressure from the government and other institutions is expected to encourage companies to be more serious in managing carbon emissions to avoid potential litigation for environmental damage caused by carbon emissions. This will ultimately increase the carbon risk exposure of companies that do not comply with government carbon policies.

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Carbon risk refers to the impact of carbon on business caused by the transition to a low-carbon economy (Rao *et al*., 2023) . Investors perceive that carbon risk may result in decreased company performance (Krueger *et al*.,)2020 such as lower firm value (Bolton *et al*., 2022) , wider yield spreads (Seltzer *et al*., 2022) , increased risk of financial distress (Damert *et al*., 2017) , as well as more likely to default (Capasso *et al*., 2020) . Therefore, carbon emissions become a risk for companies due to the perception of stakeholders, including investors, who weigh environmental damage and the possibility of reduced company performance caused by the costs incurred to comply with government carbon regulations (Shu *et al*.,)2023 . Dijk *et al*. (2021)) suggest four types of carbon risk proxies, namely absolute levels or volumes of carbon emissions, carbon intensity (emissions measured by financial metrics such as revenue or assets), climate change-related events, and carbon emissions disclosure scores or ratings.

Companies with a poor environmental profile including high carbon risk are more vulnerable to changes in environmental regulations and obligations (Zhang and Fang, 2022) . Creditors as one of the investors providing loans view vulnerability to regulatory risk as increasing the uncertainty of business conditions and increasing the risk of corporate financial distress. For creditors, this risk increases loan risk because it has the potential to cause default. Creditors demand greater compensation from the funds lent, so creditors set higher loan interest rates on companies with high carbon risk. (Jung *et al.,* 2016; Kleimeier and Viehs., 2016; Maaloul, 2018; Palea and Drogo, 2020; Pizzutilo *et al*., 2020; Al Rabab'a *et al*., 2023). A lot of empirical evidence shows that high carbon risk leads to increased debt costs, thus reducing the efficiency of borrowed capital. This condition is utilized by the government to encourage lenders to develop environmentally friendly loans (greenbonds). Companies that are able to manage carbon emissions are subject to lower debt costs, as they are seen as companies that support government interests and are considered less risky by creditors.

Endarto *et al*. 2022 stated that Indonesia's greenbonds instruments showed growth in terms of amount, which was valued at USD 1.27 billion in 2018 and increased to USD 2.75 billion in 2020. However, the results of the Asian Development Bank's 2022 survey show that the development of green finance in Indonesia is still very low. The survey found that only 5% of institutional investors hold more than 30% of greenbonds in their investment portfolio, due to a lack of environmental awareness and a lack of creditor resources to develop green bonds (Asian Development Bank, 2022) . Both studies indicate the development of green credit in Indonesia.

However, these efforts do not seem to have reached an urgent level to realize the Indonesian government's efforts to achieve net zero carbon emissions by 2060. This is evident from the volume of Indonesia's carbon emissions, which continues to increase from 535.72 tonsCO2e (Carbon Dioxide Equivalent) in 2017, to 674.54 MtonsCO2e in 2023 (Crippa *et al*., 2024). Based on this condition, an in-depth study is needed to determine the behavior of financial institutions related to the effectiveness of the government's carbon policy that seeks to realize a low-carbon economy through the greenbonds mechanism. The study is needed so that the government and companies

have a strong basis for developing strategies to reduce carbon emissions to ensure environmental sustainability. However, in Indonesia, there is no study that specifically examines carbon risk and its impact on the cost of debt using proxies for the volume and intensity of carbon emissions that are considered in line with the government's interest in reducing carbon emissions.

Nasih *et al*. (2024) examined the impact of carbon emission disclosure scores as a proxy for carbon risk on the cost of debt of companies participating in PROPER (corporate performance rating assessment program in environmental management) from 2015 to 2018. This study found that higher carbon emission disclosure scores can reduce information asymmetry between companies, creditors, and public expectations, thereby reducing debt costs. The carbon emission management report is the basis for the government to obtain information on the company's carbon emission management. Disclosure of carbon emission management is one of the mandates in POJK Number. 51/POJK.03/2017. However, carbon disclosure scores, environmental, social, and governance (ESG) disclosure scores do not fully capture companies' efforts to reduce carbon footprints (Stanny, 2008; Safiullah *et al*., 2022). Therefore, this study seeks to use two measures of carbon risk that are considered more aligned with government interests, namely the volume and intensity of carbon emissions

This study aims to analyze the impact of the government's interest in realizing a low-carbon economy on the cost of corporate debt. The cost of debt reflects creditor interests that can be influenced by carbon risk, where high carbon risk leads to higher debt costs. This condition is expected to encourage companies to reduce emissions to obtain low risk perception from creditors, so that they can get loans at a lower cost. Carbon risk is proxied by the volume and intensity of carbon emissions. This study fills the gap in empirical evidence related to the impact of carbon emissions on the cost of debt of non-financial companies in Indonesia. The results are expected to help companies strategize on appropriate carbon performance and become a consideration for the government in formulating effective greenbonds policies.

This study examines the impact of carbon risk on the cost of debt of 255 public companies in the non-financial sector in Indonesia from 2017 to 2023. This study found that in general, carbon risk has not been considered by creditors in the decision of the cost of corporate debt, so the government must work harder to encourage financial institutions to issue environmentally friendly credit instruments. This is so that through green credit instruments the government can encourage companies to reduce carbon emissions to obtain debt funding from greenbonds at a low cost of debt. Companies must also proactively anticipate implementing strategies to reduce carbon emissions to balance value creation for creditors and value creation for the government as the company's main stakeholder in order to gain a competitive advantage, thus ensuring the sustainability of the company. The remainder of this paper is organized as follows. The second section describes the literature review, data and research methodology, while the third section reports and discusses the empirical findings. The last section contains conclusions, limitations and research suggestions.

THEORY REVIEW

According to Freeman's (1984) stakeholder theory, companies can achieve long-term sustainability if they are able to implement proactive and anticipatory strategies to environmental changes. Companies must demonstrate commitment in creating and maintaining value for key stakeholders such as shareholders, employees, customers, suppliers, communities, creditors, and governments. This strategy gives the company a competitive advantage and increases the chances of business sustainability. Donaldson and Preston (1995) added that good relationship management with key stakeholders can improve the reputation and economic success of the company. Stakeholder theory helps manage conflicts of interest in the formation of corporate environmental policies, so that they are in line with the demands of various parties (Freeman, 1984). Kabir *et al*. (2021) state that responding to stakeholder concerns for the environment, such as reducing carbon emissions, can increase company value and performance. Lieu *et al*. (2024) found that good climate governance reduces carbon emissions in energy companies in 91 countries. The global commitment to reducing carbon emissions also continues to strengthen (Zang *et al*., 2025).

Wang (2023) showed that green financial policies, such as green credit guidelines, can limit financing for high-polluting firms and promote environmental protection. Liu *et al*. (2019) add that environmental ratings from the government make it easier for green companies to obtain long-term loans at lower costs. This emphasizes the importance of the government's role as a key stakeholder in encouraging sustainable financing practices.

Sundaran and Hansen (2023) also emphasize that the government expects companies to actively reduce carbon emissions as part of climate change mitigation efforts, which in turn supports corporate and environmental sustainability.

The government encourages financial institutions to develop *green* financing such as greenbonds, and lenders are expected to consider a company's carbon performance when providing loans. Shu *et al*. (2022) explain that companies with high carbon risk face additional costs to comply with carbon regulations, which can reduce profits and the ability to repay debt. Cumming (2023) and Kabir (2021) state that companies that reduce carbon emissions can gain a competitive advantage through increased access to financing at a lower cost. Nguyen (2020) adds that socially responsible investors tend to avoid companies with high carbon intensity, thus increasing their cost of capital. Empirical evidence shows that creditors take carbon policy risk into account in debt pricing, making carbon emissions an important risk factor in corporate financing.

The cost of debt reflects the return that creditors expect considering default risk, interest rates, and tax protection benefits, and is part of the firm's cost of capital (Fama and French, 2002). Companies with poor environmental performance are more vulnerable to environmental regulations and liabilities (Zang and Fang, 2022). Carbon regulations may limit access to finance as creditors assign higher debt costs to firms with high carbon risk (Shu *et al*., 2022). Creditors perceive high-emission projects as more financially risky because regulatory compliance entails additional costs. Carbon

policies also cause financial markets to devalue high-emitting companies, increasing the cost of capital (Bolton *et al*., 2022). This risk is ultimately passed on to borrowers through increased debt costs (Palea and Drogo, 2020; Pizzutilo *et al*., 2020; Goss and Roberts, 2011).

HYPOTHESIS

Creditors view carbon-intensive projects as risky because the externalization of carbon pollution impacts climate change to the detriment of society at large (Maaloul, 2018, Pizzutilo *et al*., 2020). Creditors also face exposure to corporate carbon risk as they bear the costs of borrower default, and still face reputational risk of lending capital to environmental polluters (Jung *et al*., 2016). Bolton *et al*. (2022) explain that investors are risk-averse, so investors actively seek ways to reduce their exposure to climate-related risks and demand compensation appropriate to the risk received and engage to minimize risks. The carbon premium appears in higher returns as compensation for higher exposure to carbon risks.

Research aimed at examining the impact of carbon emissions on the cost of debt, for example, Palea and Drogo (2020) found that companies with a higher carbon emissions ratio have a higher cost of debt and the relationship between carbon emissions and the cost of debt became clearer after the implementation of the Paris Agreement in 2015. Jung *et al*. (2018) show that companies in Australia experience an increase in the cost of debt at high scope 1 carbon emissions. Companies that do not voluntarily declare their emissions are classified as high emitters. While other studies provide different conclusions. For example, Zhou *et al*. (2018) found a non-linear relationship (*u-shape*) between emissions and corporate debt costs in China in 2011-2015. The non-linear relationship is influenced by the role of the media as a proxy for corporate reputation. Interestingly, Ding *et al*. (2023) found that carbon emissions do not affect the cost of acquiring debt for non-financial companies in China, but reduce the amount of bank loans. Kleimeier and Viehs (2016) and Maaloul (2018) found that the volume of carbon emissions is positively related to the cost of corporate debt.

Kleimeier and Viehs (2016) find that Scope 1 carbon emissions increase yield spreads on loans, especially in high-emission industries, as lenders start to consider environmental performance in credit scoring. Maaloul (2018) showed that in Canada, each additional ton of greenhouse gas emissions increases the cost of debt by 11-15%. Pizzutilo *et al*. (2020) found that a 100 basis point reduction in the carbon intensity of large companies in the STOXX Europe 600 index lowers the total cost of debt by 16 points. Palea and Drogo (2020) confirmed that lenders charged higher risk premiums to companies with high emissions, even in the most polluting sectors before the Paris Agreement. Koutoupis *et al*. (2023) show that external guarantees of greenhouse gas emissions and *gender* diversity significantly reduce the cost of debt of international companies from 2015 to 2021 and argue that greenhouse gas guarantees reduce information asymmetry and signal a long-term commitment to excellence. Meanwhile, companies in Asia-Pacific countries that have better carbon performance tend to have lower debt costs (Al Rabab'a *et al*., 2023).

The volume of carbon emissions is a measure used in carbon tax and trading policies and is therefore important to report. However, in 2020 only 37% of non-financial companies in Indonesia disclosed carbon emission volumes. The volume of carbon emissions is also a benchmark for the realization of a low-carbon economy, because a low-carbon economy can only be realized if the volume of carbon emissions can be reduced to the level expected by the government and world institutions such as (United Nations Framework Convention on Climate Change = UNFCC). On the other hand, the Indonesian government has set a commitment in the Nationally Determined Contribution (NDC) to achieve net zero emission by 2060 (menlhk.go.id). The target is clearly measured by the volume of carbon emissions, so the volume of carbon emissions is a company risk and a study is needed on how the volume of carbon emissions impacts the company's financial performance.

The previous explanation shows that the volume of carbon emissions is a measure that aligns with the Indonesian government's target of realizing a low-carbon economy. We argue that the volume of carbon emissions can be used to analyze a company's carbon emission reduction efforts by testing for firm-time fixed effects. In this case, companies that implement carbon emission reduction policies over time are aligned with the government's interest in reducing carbon emissions, so it should be a concern for creditors in determining the cost of corporate debt.

The descriptions and research results that have been described indicate that creditors include information on the volume of corporate carbon emissions as a loan risk. Creditors anticipate the possibility of default of borrowing companies by increasing loan conditions by charging high debt costs for companies with high carbon emission volume levels, so the first hypothesis formulation of this study is stated as follows.

H_1: The volume of carbon emissions has a positive effect on increasing the cost of corporate debt.

The volume of carbon emissions is a measure that is in line with the government's interest in reducing the volume of carbon emissions. However, companies' carbon releases tend to be proportional to production levels, making it difficult to compare carbon performance across companies (Hoffmann and Busch, 2008). Companies seeking to reduce the volume of carbon emissions while maintaining or increasing profitability must replace production equipment with more fossil fuel-efficient production equipment or use renewable energy sources to reduce the volume of carbon emissions. These efforts to reduce carbon emission volumes can result in a reduction in the company's carbon intensity from scope 1 carbon emission volumes. Other efforts to reduce the volume of carbon emissions can be done by purchasing lower carbon raw materials or purchasing energy from electricity suppliers so as to reduce the volume of scope 2 carbon emissions. Aswani *et al*. (2023) and Nordhaus, (2019) emphasize that the carbon intensity proxy can be a more appropriate measure to capture the comparison of carbon use efficiency between companies.

Hoffmann and Busch (2008) state that carbon intensity metrics reflect a company's carbon efficiency and increase transparency among companies in terms of emissions management. Evaluation based on carbon intensity provides insight into a company's

ability to manage emissions relative to its business activities. Carbon intensity measures physical carbon performance by comparing carbon emissions to business indicators such as sales or cost of goods manufactured, thus showing the relationship between environmental impact and company performance. Research by Li *et al*. (2014), Jung *et al*. (2016), Maaloul (2018), Palea and Drogo (2020), Pizzutilo *et al*. (2020), and Al Rabab'a *et al*. (2023) using a measure of carbon intensity found a positive relationship between carbon emissions and the cost of corporate debt, so the second hypothesis was developed using a measure of corporate carbon intensity and is stated as follows.
H2: Carbon emission intensity has a positive effect on the company's cost of debt.

DATA AND METHODOLOGY

Based on these reasons, the research framework can be shown in Figure 1. In Figure 1 there are two independent variables and four control variables.

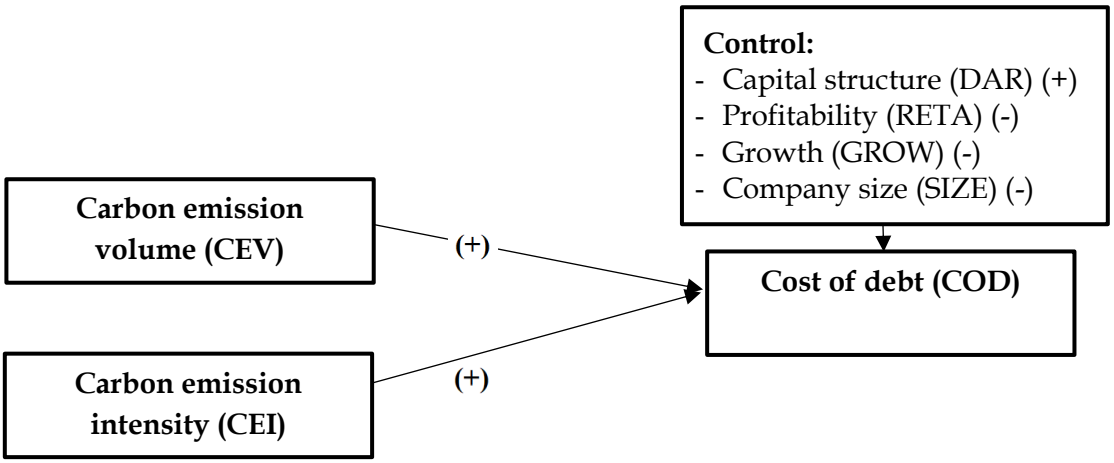

Figure 3.1 Research Conceptual Framework
Source: Author's processed results (2025)

The total research population based on 2020 data is 662 non-financial companies listed on the Indonesia Stock Exchange. The sampling technique in this study used purposive sampling. Selected companies publish sustainability reports on idx.co.id or on the website of each company. Based on observations in the company's sustainability report, there are 37 companies that have reported the volume of carbon emissions starting in 2017 and 333 companies in 2023 so that 1558 unbalanced observed data are obtained. Regression testing was conducted using 1023 unbalanced observational data of 255 companies from 2017 to 2023. The number of observations is obtained after deleting data on companies without bank debt costs as many as 122 companies, 372 outlier data, and removing 41 companies that only have 1 year of observed data after deleting outlier data. Companies that only have 1 year of observation cannot be tested for fixed effects regression, so they are excluded from the observation data.

This study analyzes the effect of independent variables of carbon emission volume (CEV) and carbon emission intensity (CEI) variables on the dependent variable of cost of debt (COD). This study uses the level of capital structure leverage (DAR), the level of profitability (ROA), the growth rate of firm value (GRO) and firm size (SIZE) as control variables. Variable measurements are presented in the following table.

Table 1. Research Variables

Variables	Measurement	Source
Cost of debt	Debt interest expense / total debt	Vullinghs (2021)
Carbon emission volume	*Scope 1* carbon emission volume *(direct* carbon*)* + *Scope 2* carbon emission volume *(indirect* carbon*)*	Bolton and Kacperczyk (2022)
Carbon emission intensity	Carbon emission volume / *cost of revenue*	Aswani (2023)
Leverage capital structure	Total debt / total assets	Kozak *et al*. (2022)
Profitability	Income after interest and tax / total assets	Ali *et al*. (2022)
Company growth	$(PBV_t - PBV_{t-1}) / PBV_{(t-1)}$ (PBV= Market value / book value of assets)	Lee *et al*. 2023
Company size	Natural log of total assets	Kim *et al*. (2019)

Hypothesis testing considers panel data fixed effects with robust standard errors clustered by firm to produce standard errors that are more robust to autocorrelation and heteroscedasticity within firm clusters (Cameron and Miller, 2015). The first model test uses the proxy of carbon emissions volume (CEV). Testing the second model uses the proxy of carbon emissions intensity (CEI) which is scaled from the ratio of carbon emissions volume to sales. The first equation in this study aims to determine how much influence the volume of carbon emissions (CEV) has on the company's cost of debt (COD) which is presented as follows.

$$\mathbf{COD}_{i,t} = \alpha_{(i)} + \beta_1 \mathbf{CEV}_{i,t} + \beta_2 \mathbf{DAR}_{(i,t)} + \beta_3 \mathbf{ROA}_{(i,t)} + \beta_4 \mathbf{GROW}_{(i,t)} + \beta_5 \mathbf{SIZE}_{i,t} + \varepsilon_{(i,t)}$$

Model 1.

The second equation in this study aims to determine how much influence carbon emission intensity (CEI) has on corporate debt costs (COD)

$$\mathbf{COD}_{i,t} = \alpha_{(i)} + \beta_1 \mathbf{CEI}_{(i,t)} + \beta_2 \mathbf{DAR}_{i,t} + \beta_3 \mathbf{ROA}_{(i,t)} + \beta_4 \mathbf{GROW}_{(i,t)} + \beta_5 \mathbf{SIZE}_{i,t} + \varepsilon_{i,t}$$

Model 2.

Robustness tests were conducted by considering the period before and after the enactment of POJK 51 of 2017 in 2020 to determine the impact of government carbon policies on corporate debt costs. The next robustness test considers the industry's carbon intensity category. According to Palea and Drogo (2020) companies with high carbon pollution are subject to higher risk premiums. According to various sources, companies in the basic materials, consumer cyclicals, industrials, properties and real

estate, energy, and transportation and logistics sectors are categorized as high carbon intensity industries, while companies in the consumer non-cyclicals, healthcare, technology and financials sectors are categorized as low carbon industries.

RESULTS AND DISCUSSION

Carbon emission data and financial data were obtained from sustainability reports and company annual reports. The total research data is 1023 observations. The statistical description of the research variables is presented in Table 2 below.

Table 2. Descriptive Statistics of Research Variables (n-1023)

Variables	Descrip.	2017	2018	2019	2020	2021	2022	2023
		(n=24)	(n=48)	(n=134)	(n=188)	(n=204)	(n=215)	(n=210)
COD (%)	Mean	6.21	6.35	8.06	7.88	7.24	7.16	8.02
	Std	2.12	2.89	2.91	3.40	3.47	3.04	3.06
	Median	6.26	6.17	7.90	7.85	6.93	7.02	7.83
CEV	Mean	2.522	1.847	1.378	661	695	625	691
($MTonCo_{(2)\,e}$)	Std	5.460	4.438	6.622	2.421	2.577	2.368	2.507
	Median	413	165	64	62	46	40	59
CEI (%)	Mean	42.42	41.32	38.71	38.75	38.10	37.21	37.79
	Std	8.67	7.65	8.79	8.37	8.29	8.87	8.43
	Median	44.68	40.59	38.43	39.27	38.39	37.61	38.84
DAR (%)	Mean	31.95	32.24	31.00	29.30	27.68	27.29	27.64
	Std	14.17	17.04	17.06	17.94	17.56	18.50	18.27
	Median	33.14	33.46	30.46	29.48	26.96	26.20	25.40
ROA (%)	Mean	2.34	3.48	3.08	1.49	3.73	3.85	3.29
	Std	4.24	3.79	4.54	5.14	5.24	5.23	4.96
	Median	2.49	3.61	2.60	1.07	3.59	3.63	2.94
GRO (%)	Mean	66.18	87.13	81.89	78.80	84.86	76.82	72.91
	Std	26.08	50.99	46.59	45.67	49.19	43.83	40.28
	Median	63.80	73.11	72.57	69.38	71.33	66.52	63.59
SIZE	Mean	30.69	30.63	29.61	29.38	29.42	29.32	29.45
(LN of	Std	1.23	1.19	1.61	1.58	1.66	1.66	1.65
assets)	Median	31.03	30.72	29.67	29.38	29.45	29.28	29.36

DESCRIPTION: COD (cost of debt) shows the company's cost of debt, CEV (carbon emissions volume) is the total volume of the company's carbon emissions, CEI (carbon emissions intensity) is the level of intensity of the company's carbon use, namely the volume of carbon emissions compared to the cost of revenue business matrix, DAR (debt to assets ratio) is the level of use of the company's debt compared to assets, ROA (return on assets) shows the level of the company's ability to generate profits, GROWT (Growth) shows the growth of company value and SIZE (LN total asssets) shows the size of the company.

Table 2 shows that from 2017 to 2023 the average cost of debt (COD) tends to increase, while carbon emission volume (CEV) and carbon emission intensity (CEI) tend to decrease. The volume of carbon emissions (CEV) tends to have a standard deviation that is higher than the average, indicating the high spread of carbon emission volume data between companies. The company's debt-to-asset level (DAR) shows an

average of around 30%, indicating that non-financial companies in Indonesia tend to use low capital leverage. The average debt-to-ass*et al*so shows a decreasing trend, indicating that companies in Indonesia avoid issuing debt, which can be caused by higher debt costs. Nonetheless, Table 2 also shows an increasing trend of profit (ROA) and companies experiencing a better growth rate (GROWT) even though company assets (SIZE) tend to decrease.

Table 3. Correlation Matrix of Research Variables (n=1023)

	CEV	CEI	DAR	ROA	GRO	SIZE
COD	0.0324	0.0259	-0.2695***	0.0038	-0.0805**	-0.1810***
CEV		0.9904***	-0.0824***	0.0676**	0.0011	0.0513
CEI			-0.0687**	0.0440	-0.0064	0.0014
DAR				-0.3108***	0.0294	0.1157***
ROA					0.1508***	0.0450
GROW						0.0671**

Notes: Table 3 presents the correlations between the research variables. The ***, ** and * indicate the significance of the correlation at the 1%, 5% and 10% levels.

Table 3 presents the correlation matrix of the research variables. The correlation between company size (SIZE) and carbon emission volume (CEV) is categorized as strong and positive, indicating that a company's carbon emissions are more determined by the size and production volume of the company, so the larger the company, the greater the volume of carbon emissions. The correlation table also shows a very strong relationship between the variables of carbon emission volume (CEV) and carbon emission intensity (CEI), which is the reason for separating the two carbon risk proxies into two research models.

The fixed effects regression test results based on Model 1 equation and Model 2 equation are summarized and presented in Table 4 below.

Table 4.Summary of *Fixed Effects* Regression Test Results

Variables	Predict.	Single Regression		Model 1	Model 2
Constant	+	0,6457* (10,99)	0,06679*** (13,17)	0,5387** (2,57)	0,5355** (2,54)
CEV	+	0,0009 (1,88)		0,0007 (1,14)	
CEI	+		0,0224 (1,74)		0,0096 (0,63)
DAR	+			-0,1026*** (-10,11)	-0,1031*** (-10,07)
ROA	-			-0,0641** (-2,86)	-0,0635** (-2,83)
GROW	-			-0,0069** (-2,52)	-0,0070** (-2,51)
SIZE	-			-0,0147* (-2,08)	-0,0145* (-2,05)

Variables	Predict.	Single Regression		Model 1	Model 2
F:		3,52	3,02	254,4***	196,5***
R^2:		0,0012	0,0007	0,0975	0,0971

Notes: Table 4 presents the regression coefficient numbers and t-values are presented in parentheses. The ***, ** and * indicate the significance of the correlation coefficient at the 1%, 5% and 10% (*1-tailed*) level.

Table 4 shows the test results of the fixed effects of carbon risk proxied by carbon emission volume (CEV) and carbon emission intensity (CEI) on the cost of debt (COD). The regression test results show that carbon emission volume and carbon emission intensity have no impact on increasing the company's cost of debt. The control variables DAR which shows the level of leverage, ROA which shows the level of profit, the level of company growth (GROW) and the variable size of the company (SIZE) have an impact on reducing the cost of debt.

The fixed effects test shows that an increase in the volume and intensity of carbon emissions has no impact on increasing the company's cost of debt, thus indicating that the decision on the cost of debt charged by creditors to borrowing companies does not consider the company's carbon risk. These findings are unable to corroborate the findings of previous studies that concluded that corporate carbon risk has an impact on increasing the cost of corporate debt by (Jung *et al.,* 2016; Kleimeier and Viehs., 2016; Maaloul, 2018; Palea and Drogo, 2020; Pizzutilo *et al*., 2020; Al Rabab'a *et al*., 2023).

The control variables show that an increase in leverage, an increase in profit, growth in company assets and company size have a negative impact on the cost of debt. This impact shows that creditors consider the company's financial fundamentals in the decision to lend to the company. Companies that are able to use debt to increase profits, increase growth, and companies that have larger assets are considered less risky, so creditors set lower debt costs. An increase in the company's capital leverage also has an impact on reducing the cost of debt, while according to Kozak (2021) an increase in capital leverage increases the risk of bankruptcy, resulting in an increase in the risk premium demanded by creditors, namely higher debt costs. The findings of this study indicate that an increase in leverage actually has an impact on reducing the cost of debt, which can be expected due to the company's ability to use debt to generate profits and increase company growth. In addition, table 2 descriptive statistics of the research variables also shows that the average leverage level of the company is around 30% compared to the company's assets. This condition shows that non-financial companies in Indonesia use a low level of leverage, so that an increase in capital leverage is seen as having no impact on increasing the risk of bankruptcy because the company's profits also increase.

Robustness Test

Robustness test by considering the period before and after the enactment of POJK 51 of 2017 in 2020. The next robustness test considers the carbon emission intensity of the industry. Both tests aim to determine the difference in the impact of

these factors on the cost of debt between companies. The statistical description of the research variables considering the period before and after the enactment of POJK 51 of 2017 in 2020 as well as industrial carbon intensity is presented in Table 5 below.

Table 5. Descriptive Statistics of Robustness Test Research Variables (n-1023)

Variables	Descrip.	Implementation of POJK 51 in 2020		Industry Carbon Intensity	
		Before (n=249)	After (n=774)	Low (n=206)	High (n=817)
COD (%)	Mean	7.45	7.57	7.89	7.43
	St.dev	2.94	3.26	2.97	3.26
	Median	7.40	7.44	7.82	7.29
CEV ($MTonCo_{(2)\,e}$)	Mean	1.620	668	290	1.043
	St.dev	6.038	2.465	677	3.999
	Median	100	52	46	63
CEI (%)	Mean	39.75	37.94	36.60	38.85
	St.dev	8.60	8.50	8.07	8.63
	Median	39.63	38.37	37.19	39.08
DAR (%)	Mean	31.40	27.94	28.83	28.57
	St.dev	16.68	18.06	18.75	17.55
	Median	31.58	27.06	30.12	28.10
ROA (%)	Mean	3.09	3.13	3.39	3.04
	St.dev	4.33	5.22	5.74	4.81
	Median	2.94	2.81	3.77	2.52
GRO (%)	Mean	81.28	78.28	94.60	73.83
	St.dev	45.99	44.92	48.89	42.68
	Median	71.46	67.62	84.95	63.09
SIZE (LN of assets)	Mean	29.97	29.39	29.32	29.57
	St.dev	1.56	1.64	1.47	1.68
	Median	30.10	29.38	29.21	29.59

The robustness test by considering the period before and after the enactment of POJK 51 of 2017 in 2020 aims to determine the difference in the impact of the government's carbon policy factor, POJK No.51 of 2017, which requires public companies to publish sustainability reports in the 2020 reporting year. We expect that after the enactment of the POJK, creditors will increasingly consider the company's carbon risk, so that the company's cost of debt will be higher after POJK 51 2017 is enacted in 2020. The test is conducted by grouping data for the year before the enactment of POJK No.51, namely data for 2017, 2018, 2019 and after the enactment of POJK No. 51 for data for 2020, 2021, 2022 and 2023. The test results are presented in Table 6.

Table 6. Summary of Regression Test Results of the Applicability of POJK 51 2017

		Model 1		Model 2	
Variables	**Predict.**	**Before**	**After**	**Before**	**After**
Constant	+	0,3228 (0,88)	0,5627** (2,99)	0,3203 (0,88)	0,5560** (2,92)
CEV	+	-0,0015* (-1,93)	0,0011 (1,46)		
CEI	+			-0,0664*** (-3,98)	0,0231 (1,18)
DAR	+	-0,0982*** (-8,61)	-0,1028*** (-9,12)	-0,0983*** (-8,46)	-0,1033*** (-9,04)
ROA	-	-0,0144 (-3,42)	-0,0785*** (-3,80)	-0,0138 (-0,37)	-0,0779*** (-3,79)
GRO	-	-0,0040 (-0,77)	-0,0087* (-2,89)	-0,0040 (-0,77)	-0,0087** (-2,88)
SIZE	-	-0,0067*** (-0,53)	-0,0156** (-2,47)	-0,0063 (-0,51)	-0,0153** (-2,41)
F:		507,2***	686,7***	1364***	1237***
R^2:		0,0834	0,1069	0,086	0,1062

Notes: Table 6 presents the regression coefficient numbers and t-values are presented in parentheses. The ***, ** and * indicate the significance of the correlation coefficient at the 1%, 5% and 10% (*1-tailed*) level.

A comparison of the regression test results in Table 6 shows that before 2020, or before the implementation of POJK No. 51, the volume of carbon emissions (CEV) had a significant negative impact on the cost of debt with a significance level of 10%. The volume of carbon emissions actually had an impact on reducing the cost of debt before POJK No.51 was implemented. After the implementation of POJK No.51 in 2020, carbon emissions had a positive but insignificant effect with a significance value of 19.4%. Table 6 also shows that carbon emission intensity (CEI) has a significant negative impact on the cost of debt variable. Carbon emission intensity actually had an impact on lowering the cost of debt before the enactment of POJK No.51. After the enactment of POJK No.51 of 2017, the regression results show an insignificant positive impact, with a significance value of 29.3%. The change in the negative impact of carbon emission volume and carbon emission intensity before the implementation of POJK No. 51 to positive after the implementation of POJK No. 51 although not significant, the change from significant negative to insignificant positive indicates that creditors began to consider carbon risk in the company's debt cost decision after the implementation of POJK No.51 in 2020. The government's carbon policy increases the perception of possible future creditor losses. The possibility of creditor losses is perceived from the increased costs that must be incurred by the company to comply with government carbon regulations which can cause the company to default on loans, so the impact of carbon risk on the cost of debt becomes positive after the enactment of POJK No.51 in 2020

The next test considers the carbon intensity of the industry. The test aims to determine the difference in the cost of debt between companies engaged in low-carbon industries and companies engaged in high-carbon industries. We suspect that creditors perceive companies engaged in industries with high carbon emission intensity as riskier, so that the cost of debt of companies in the high carbon intensity category is higher than companies engaged in low carbon emission intensity industries. A summary of the regression test results considering the industry carbon intensity category is presented in Table 7.

Table 7 Summary of Regression Test Results
Companies in Low Carbon and High Carbon Industries

		Model 1		**Model 2**	
Variables	**Predict.**	**Low**	**High**	**Low**	**High**
Constant	+	-0,7100* (-4,11)	0,6941** (4,12)	-0,7190* (-4,04)	0,6780** (3,79)
CEV	+	0,0009 (0,95)	0,0022 (1,33)		
CEI	+			0,0282 (0,95)	0,0403 (0,86)
DAR	+	-0,1164* (-10,14)	-0,1276*** (-14,72)	-0,1168* (-9,87)	-0,1280*** (-14,37)
ROA	-	-0,1427 (-11,31)	-0,0758 (-1,94)	-0,1432*** (-11,42)	-0,0741 (-1,92)
GRO	-	-0,013* (-3,56)	-0,0080 (-1,88)	-0,013* (-3,60)	-0,0082 (-1,93)
SIZE	-	0,0275** (4,90)	-0,0203** (-3,02)	0,0278** (0,83)	-0,0195 (-3,42)
F:		1355***	100,5***	69,2**	223***
R^2:		0,175	0,135	0,175	0,133

Notes: Table 7 presents the regression coefficient numbers and t-values are presented in parentheses. The ***, ** and * indicate the significance of the correlation coefficient at the 1%, 5% and 10% (*1-tailed*) level.

A comparison of the regression test results in Table 7 shows that carbon emission volume and carbon emission intensity in low-carbon industries and high-carbon industries do not significantly affect the cost of debt. Although not significant, the significance value shows that it is getting better in the high carbon intensity category. In Model 1, the significance of carbon emission volume (CEV) in low-carbon industries shows a significance value of 44.1% and the significance value in high-carbon industries is 27.5%, which indicates that there is an increase in the impact of carbon emission volume on the cost of debt more impact on industries with high levels of carbon emission pliers. In model 2, the significance of carbon emission intensity (CEI) in low-carbon industries shows a significance value of 44.4% and a significance figure in high-carbon industries worth 45.2%. The significance value in industries with low carbon emission intensity is not much different from companies in the high carbon

emission intensity category. The findings in model 1 indicate that creditors increasingly consider the carbon risk of companies engaged in high-carbon industries.

DISCUSSION

The results of hypothesis testing show that carbon risk, proxied by the volume of carbon emissions or the intensity of carbon emissions, has no impact on increasing the cost of corporate debt. Creditors have not fully included carbon risk in determining the cost of corporate debt and pay more attention to the company's fundamental performance. Fama and French (2002) state that the cost of debt is the return expected by creditors by considering the risk of corporate default. Creditors view companies that have good fundamental performance as less risky. Companies that are able to utilize debt to increase profits, increase growth and enlarge company assets are considered less risky. Aswani *et al*. (2023) and Nordhaus (2019) argue that the volume of corporate carbon emissions is largely determined by production volume, so efforts to increase corporate profits and growth by increasing the amount of corporate assets from debt capital lead to increased corporate carbon emissions. This suggests that creditors' interests, which are reflected in the cost of debt, only consider the company's fundamental performance and ignore carbon risk, as it increases the volume of the company's carbon emissions. Nonetheless, the robustness test on industries with high carbon category shows a better significance value, suggesting that the impact of carbon emission volume on the cost of debt is more pronounced for companies operating in the high carbon industry sector category. According to Palea and Drogo (2020) companies with high carbon pollution are subject to higher risk premiums, so creditors demand greater compensation by imposing higher levels of debt costs.

Tests conducted using data before the enactment of POJK No.51 in 2017, the volume and intensity of carbon emissions had a significant negative impact on the company's cost of debt, then reversed the positive insignificant impact after it was enacted in 2020. The findings suggest that the enactment of the government's carbon policy through POJK No.51 may encourage creditors to start considering carbon risk in the decision of the cost of debt charged to borrowing companies. The change from significant negative to insignificant positive indicates that carbon emissions are less impactful after the implementation of government carbon regulation. Shu *et al*. (2022) stated that companies with high carbon risk face higher additional costs to comply with carbon regulations, which can reduce profits and the ability to pay debt, so the carbon risk arising from government carbon policies further increases the cost of corporate debt.

In general, the findings of this study confirm the results of ADB's 2022 survey which concluded that the development of greenbonds by financial institutions in Indonesia has not shown urgent efforts to support efforts to reduce business sector carbon emissions. Financial institutions in Indonesia do not have sufficient capital to develop green credits, so companies are not motivated to develop projects related to renewable energy development to support the government's carbon policy. The lack of incentives for companies to develop projects to reduce carbon emissions is suspected to be the reason why green credit is underdeveloped, so carbon emissions do not significantly affect the cost of debt of non-financial companies in Indonesia.

CONCLUSION

This study analyzes the government's interest in realizing a low-carbon economy, and its impact on the cost of corporate debt. The government's interest is proxied by the volume of carbon emissions and the intensity of carbon emissions,

while the interest of creditors who are also affected by corporate carbon risk is proxied by the cost of corporate debt. The hypotheses are tested by regressing 1023 unbalanced data obtained from observations of 255 non-financial companies on the Indonesia Stock Exchange that reported carbon emission volumes from 2017 to 2023

This study concludes that carbon risk has not been fully considered by creditors in determining the cost of corporate debt. Hypothesis testing findings show that increasing the volume and intensity of carbon emissions has not significantly affected the cost of debt of non-financial companies in Indonesia. This suggests that government regulations to reduce carbon emissions have not effectively involved creditors in encouraging green financing. As a result, the net zero emission target is potentially hampered because carbon risk is not considered financially detrimental by creditors who still rely on conventional indicators such as leverage, profitability, growth, and company size. This condition does not incentivize companies to reduce carbon emissions. In the context of stakeholder theory, the government and creditors play an important role in promoting business sustainability. The government as the main stakeholder has the authority to regulate through carbon taxes, carbon trading, or revocation of business licenses to ensure that companies do not harm the public interest.

LIMITATIONS AND FUTURE RESEARCH

We recognize the limitations of this study. First, this study only examines two stakeholders that influence and are influenced by corporate carbon emissions, namely the government and creditors. Future research could examine other stakeholders that are also affected by corporate carbon risk, such as shareholders, employees, suppliers, consumers and non-governmental organizations that are also affected by corporate carbon emissions. Future research can also examine the impact of stakeholders on capital structure policy because the cost of debt is related to the cost of capital, so it has an impact on the company's capital structure policy. On the other hand, studies on how financial institutions behave in the capital market in response to corporate carbon emissions are also needed because financial institutions play a major role in efforts to reduce corporate carbon emissions.

The second limitation is that this study only examines companies that report carbon emission volume, which is 255 companies, while the number of non-financial companies listed on the Indonesia Stock Exchange data in 2020 is 662 companies. Future research can also examine the difference in debt costs between companies that report carbon emission volumes and companies that do not report carbon emission volumes in order to provide a broader picture of company and creditor behavior related to carbon risk.

Comparisons can also be made with companies that voluntarily reported carbon emission volumes before it was required by the government. Companies that report carbon emission volumes before it is required by the government are considered as companies that implement anticipatory proactive strategies in accordance with strategic management in stakeholder theory. Finally, we welcome criticism and

suggestions for research improvement in order to improve the quality of academic studies to support the government's efforts to realize a low-carbon economy.

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