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Determinants of Carbon Emission Disclosure Among Indonesian SOEs: Empirical Evidence from Firm Size and Leverage Dynamics (2021–2024)

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ABSTRACT

This study examines the influence of firm size and leverage on carbon emission disclosure among Indonesian State-Owned Enterprises (SOEs) during the period 2021–2024. Using secondary data obtained from sustainability and annual reports, this research adopts a quantitative associative approach with a sample of nineteen SOEs, resulting in seventy-six firm-year observations. Carbon emission disclosure is measured using a comprehensive index based on the Global Reporting Initiative (GRI) 305 Emissions standard, employing a structured content analysis of thirty-seven disclosure items. Multiple linear regression analysis is conducted after fulfilling classical assumption tests, including normality, multicollinearity, and heteroskedasticity diagnostics. The findings indicate that firm size is positively associated with carbon emission disclosure, suggesting that larger enterprises tend to disclose carbon-related information more extensively. In contrast, leverage is negatively associated with disclosure, indicating that firms with higher debt levels are less inclined to engage in voluntary carbon reporting. These results highlight the joint role of organisational scale and financial structure in shaping environmental transparency. To ensure robustness, additional analyses are performed using alternative variable proxies, winsorisation of extreme values, heteroskedasticity-consistent estimators, extended models with control variables, and panel data specifications. The results remain consistent across alternative estimations. This study addresses a gap in the literature by focusing exclusively on State-Owned Enterprises, which operate under heightened public accountability yet remain underexplored in carbon disclosure research. The key novelty lies in demonstrating that financial constraints, reflected through leverage, constitute a more persistent determinant of carbon emission disclosure than organisational size within publicly owned enterprises. This study is subject to limitations related to its SOE-specific focus and reliance on report-based disclosure data, providing avenues for future research in broader ownership and institutional contexts.

Keywords: Carbon Emission Disclosure; Firm Size; Leverage; State-Owned Enterprises

INTRODUCTION

Climate change and global warming have emerged as critical global challenges, garnering extensive international attention due to their profound environmental implications. The increase in the Earth's average temperature is primarily driven by human activities, particularly through carbon dioxide emissions from fossil fuel consumption, including oil and natural gas (Jamil & Inayah, 2023). The continuous accumulation of these greenhouse gases exacerbates global warming, prompting numerous international agreements aimed at mitigating emissions and fostering collaborative efforts to combat climate change (Jamil & Inayah, 2023). Regulatory frameworks are essential for encouraging countries to adopt sustainable practices, especially in nations with significant industrial activities.

In Indonesia, carbon dioxide is the largest contributor to the nation's greenhouse gas emissions.

Notably, the electricity generation and industrial processing sectors significantly contribute to these emissions, reflecting the country's reliance on fossil fuels (Cahya, 2017). Recent data indicate a concerning trend of increasing emissions in Indonesia; for instance, industrial emissions rose from 747.578 Gg CO_2e in 2020 to 887.232 Gg CO_2e in 2022 (Mangara Yudha et al., 2023). This increase underscores the environmental impact of energy and industrial activities in Indonesia and raises critical questions about corporate transparency and the reporting of carbon emissions. The manufacturing sector has shown significant growth, while the electricity and gas supply sector has maintained persistently high emission levels. These trends necessitate enhanced corporate responsibility and transparent reporting of emission levels to align with environmental standards (Cahya, 2017; Mangara Yudha et al., 2023).

The importance of corporate transparency in environmental performance is paramount, particularly regarding carbon emission disclosures. Such disclosures, often included in sustainability or annual reports, enable companies to communicate their commitment to environmental responsibility effectively (Camilleri, 2015). In Indonesia, although carbon emission reporting is a voluntary practice, it plays a crucial role in fostering accountability, especially for companies whose operations significantly affect the environment (Aksan & Gantyowati, 2020). State-Owned Enterprises (SOEs), as key players in the national economy, have additional responsibilities for environmental transparency due to their strategic role in national development (Camilleri, 2015). As public entities, SOEs are subject to heightened expectations regarding their environmental stewardship, necessitating comprehensive disclosure of their emissions (Cahya, 2017).

From a theoretical perspective, carbon emission disclosure can be explained through legitimacy theory, stakeholder theory, and signaling theory. Legitimacy theory posits that firms disclose environmental information to align their activities with societal norms and maintain social acceptance, particularly when their operations pose substantial environmental risks (Clarkson et al., 2008; Prado-Lorenzo & Garcia-Sanchez, 2010). Stakeholder theory emphasises that firms respond to the demands of stakeholders who possess the power to influence organisational outcomes, such as regulators, investors, and the public, by providing relevant environmental information (Choi et al., 2013). Meanwhile, signaling theory suggests that voluntary disclosure functions as a signal of superior environmental performance or responsible management, aimed at reducing uncertainty and enhancing corporate reputation (Michelon et al., 2015).

Internal organizational factors such as firm size and leverage are vital in shaping carbon emission disclosure practices. Research indicates that larger companies often practice broader disclosures to meet public scrutiny and stakeholder expectations (Faisal et al., 2018). Conversely, firms burdened with higher leverage may prioritize financial obligations over voluntary environmental reporting, potentially leading to deficits in transparency concerning their emission practices (Afrizal et al., 2023; Hapsari & Prasetyo, 2020). The mixed findings in the existing literature highlight the complexity of these relationships, suggesting a need for further empirical investigation within the context of Indonesian SOEs (Faisal et al., 2018; Wang, 2023).

Despite the growing literature, a clear empirical and theoretical gap remains. Most prior studies examine carbon emission disclosure using mixed samples of private and public firms, implicitly assuming that disclosure incentives operate uniformly across ownership structures. However, State-Owned Enterprises differ fundamentally from private firms in terms of governance mechanisms, political oversight, and public accountability, making such generalisations problematic (Yuhertiana et al., 2025). Furthermore, firm size and leverage are often treated merely as control variables rather than being analysed for their relative explanatory power under heightened legitimacy pressure and post-pandemic ESG regulation. In addition, many Indonesian studies rely on simplified disclosure indices and seldom conduct robustness tests, limiting confidence in their empirical conclusions (Faisal et al., 2018).

This study addresses these unresolved issues by focusing exclusively on Indonesian State-Owned Enterprises during the 2021–2024 period and employing a comprehensive carbon emission disclosure index based on the Global Reporting Initiative (GRI) 305 Emissions standard, which consists of thirty-seven disclosure items. Methodologically, this research advances prior studies by implementing extensive robustness checks, including alternative proxies, heteroskedasticity-

consistent estimators, winsorisation procedures, and panel data techniques. The novelty of this study lies in demonstrating that leverage emerges as a more persistent and robust determinant of carbon emission disclosure than firm size across multiple model specifications, suggesting that financial structure may outweigh visibility effects in shaping disclosure behaviour within SOEs.

By explicitly integrating legitimacy theory, stakeholder theory, and signaling theory within the context of public ownership, this study contributes theoretically by extending established disclosure theories to State-Owned Enterprises in emerging economies. Empirically, it provides evidence on how organisational scale and financial constraints interact under increasing ESG regulatory pressure. Practically, the findings offer insights for policymakers and regulators seeking to strengthen carbon disclosure frameworks and promote consistent environmental transparency among SOEs.

LITERATURE REVIEW

Carbon Emission Disclosure and Theoretical Perspectives

Carbon Emission Disclosure refers to the voluntary or mandatory communication of information related to greenhouse gas emissions, mitigation strategies, and climate related risks in corporate reports. Such disclosure is commonly guided by international frameworks such as the Global Reporting Initiative GRI 305, the GHG Protocol, and increasingly by ESG related regulatory standards. Carbon disclosure serves as a mechanism through which firms demonstrate accountability for their environmental externalities and signal commitment to sustainable practices.

From a theoretical standpoint, carbon emission disclosure is primarily explained by legitimacy theory, stakeholder theory, and signalling theory. Legitimacy theory posits that organisations seek to align their operations with societal norms and expectations in order to maintain social acceptance. Firms with higher environmental impacts are therefore more inclined to disclose carbon related information to justify their activities and mitigate legitimacy risks. Stakeholder theory emphasises that firms respond to the information demands of stakeholders who can affect organisational survival, such as regulators, investors, and the public. Meanwhile, signalling theory suggests that disclosure is used strategically by firms to convey positive signals regarding environmental responsibility and long term risk management, particularly in contexts characterised by information asymmetry.

These theoretical perspectives provide the foundation for examining how internal organisational characteristics influence carbon emission disclosure, especially in contexts where disclosure remains largely voluntary, such as in emerging economies.

Firm Size

Firm size is widely recognised as a central determinant of environmental and carbon emission disclosure. It reflects the scale of operations, resource availability, and the degree of public visibility faced by an organisation. Firm size is commonly measured using total assets, total sales, or revenue, with the natural logarithm of total assets frequently applied to normalise data distribution and reduce the influence of extreme values (Choi et al., 2013; Kristi & Yanto, 2020; Lee & Cho, 2021).

Extant literature consistently documents a positive association between firm size and the extent of environmental disclosure. Larger firms tend to disclose more comprehensive environmental information due to heightened public scrutiny, stronger stakeholder pressure, and greater exposure to reputational risk (Budiman et al., 2024; Nasih et al., 2019; Ramanathan, 2016). In addition, large firms generally possess superior financial and technical resources that facilitate the implementation of emission measurement systems and structured sustainability reporting.

Theoretical explanations for this relationship are rooted primarily in legitimacy and stakeholder theories. Larger firms face stronger legitimacy demands due to their broader environmental footprint and visibility, which encourages them to enhance disclosure to maintain social approval. At the same time, their extensive stakeholder networks increase pressure for transparent communication of carbon related risks and performance.

However, prior studies also suggest that the influence of firm size may vary across industries, as firms operating in environmentally sensitive sectors such as energy or mining tend to disclose

more extensively than those in less scrutinised industries (Ghose et al., 2022; Nasih et al., 2019). This indicates that firm size alone may not fully explain disclosure behaviour without considering contextual factors.

Leverage

Leverage pertains to the degree to which a firm's operations are financed through debt, indicating the financial risk assumed by the company and demonstrating to what extent its assets are funded by external sources. The Debt to Asset Ratio is a widely recognized measure of leverage that compares total liabilities to total assets, where a higher ratio signifies a greater reliance on debt financing (Kristi & Yanto, 2020; Suhardi, 2025). Such leverage can adversely affect a firm's ability to allocate resources for voluntary sustainability disclosures, as firms with elevated debt levels may prioritize debt repayment over environmental reporting initiatives (Kholmi et al., 2020; Wiyarni et al., 2022).

Evidence from empirical research suggests that significant leverage correlates with lower carbon emission disclosures (Halimah & Yanto, 2018). In the context of Indonesian companies, higher leverage was found to be a deterrent to comprehensive environmental disclosure, as companies may perceive such reporting as an additional financial burden rather than a necessary obligation (Kholmi et al., 2020). Consequently, understanding the influence of leverage on carbon emissions disclosure is essential for investors and policymakers who aim to foster corporate accountability (Budiman et al., 2024; Widianto & Sari, 2020). Conversely, some studies argue that leverage can encourage transparency as a means of reducing information asymmetry and maintaining creditor confidence. These conflicting findings indicate that the role of leverage in shaping carbon disclosure remains an unresolved empirical issue, particularly in institutional contexts where disclosure obligations differ across ownership structures.

Empirical Evidence from Emerging Markets and State-Owned Enterprises

Empirical evidence on the determinants of carbon emission disclosure in emerging markets reveals mixed and often inconclusive results, particularly regarding the roles of firm size and leverage. Several studies indicate that firm size positively influences carbon disclosure due to greater public visibility and regulatory scrutiny, while leverage tends to constrain disclosure as firms prioritise financial stability over voluntary reporting (Alamanda & Azis, 2025; Choi et al., 2013; le Luo et al., 2013).

However, the direction and magnitude of these relationships appear to vary substantially across sectors and institutional contexts. (Budiman et al., 2024) report that, within the manufacturing sector, leverage exhibits a positive effect on carbon emission disclosure, while firm size shows a negative association. In contrast, studies focusing on energy and industrial sectors demonstrate that firm size is positively related to disclosure, whereas leverage consistently shows a negative influence (Alamanda & Azis, 2025). In the mining sector, both firm size and leverage are found to significantly affect carbon disclosure, suggesting that firms with larger scale and higher financial exposure may face stronger pressure to report environmental impacts (Suhardi, 2025).

These inconsistent findings indicate that sectoral characteristics, regulatory exposure, and ownership structure may moderate the relationship between financial attributes and disclosure behaviour. This complexity is particularly evident in State-Owned Enterprises, where environmental transparency is increasingly emphasised but financial and political constraints coexist (Wallad & Darniaty, 2023).

Focusing specifically on Indonesian SOEs, (Jamil & Inayah, 2023) find that state-owned firms demonstrate a stronger commitment to carbon emission disclosure compared with non-state entities, largely due to heightened public accountability and regulatory expectations. This evidence supports the argument that public ownership intensifies legitimacy and stakeholder pressures. At the same time, (le Luo et al., 2013) suggest that firms with higher leverage may resist disclosing detailed carbon information due to concerns over financial risk exposure, reinforcing the relevance of agency-based explanations.

Recent evidence by (Suhardi, 2025) further confirms that both firm size and leverage significantly influence carbon emission disclosure among Indonesian SOEs, underscoring the need

to reassess these relationships under evolving ESG regulations and post-pandemic governance reforms. Collectively, these studies highlight an unresolved empirical issue regarding how organisational scale and financial structure interact to shape carbon disclosure practices in publicly owned enterprises.

Table 1. State-of-the-Art of Carbon Emission Disclosure Studies

Author	Context	Method	Key Variables	Main Findings	Identified Gap
(Clarkson et al., 2008)	Developed countries	Content analysis	Environmental performance, disclosure	Strong link between performance and disclosure	Limited focus on emerging markets
(Choi et al., 2013)	Global firms	Regression analysis	Firm size, leverage, GHG disclosure	Firm size significant, leverage mixed	No focus on SOEs
(Prado-Lorenzo & Garcia-Sanchez, 2010)	Europe	Panel regression	Size, ownership, emissions	Size positively affects disclosure	Limited governance analysis
(L. Luo & Tang, 2016)	International sample	Panel data	Carbon disclosure determinants	Size significant, leverage inconsistent	SOEs not examined separately
(Michelon et al., 2015)	International firms	ESG scoring	Disclosure quality	Institutional context matters	Lack of SOE specific analysis
(Nasih et al., 2019)	Indonesia	Regression	Size, industry	Size positive	Simplified disclosure index
(Budiman et al., 2024)	Indonesia (Manufacturing)	Regression	Size, leverage	Leverage positive, size negative	Sector-specific, not SOEs
(Alamanda & Azis, 2025)	Energy & industry	Regression	Size, leverage	Size positive, leverage negative	No ownership distinction
(Wallad & Darniaty, 2023)	Indonesia	Descriptive-regression	ESG, disclosure	SOEs under higher pressure	No robustness testing
(Jamil & Inayah, 2023)	Indonesian SOEs	Regression	Ownership, disclosure	SOEs disclose more	Limited variable scope
(Suhardi, 2025)	Indonesian SOEs	Panel regression	Size, leverage	Both significant	No robustness checks

Source: Author's computation

Despite the growing body of literature on carbon emission disclosure, several critical gaps remain unresolved. First, most prior studies focus on private firms or mixed ownership samples, offering limited insight into the distinctive institutional and governance context of State-Owned Enterprises. Second, firm size and leverage are frequently treated as control variables rather than being examined for their relative explanatory power under heightened public accountability and ESG regulatory pressure. Third, existing Indonesian studies commonly rely on simplified disclosure indices and rarely conduct robustness tests to assess the stability of their findings across alternative specifications.

This study addresses these gaps by focusing exclusively on Indonesian State-Owned Enterprises during the 2021–2024 period and employing a comprehensive carbon emission disclosure index based on GRI 305, consisting of thirty-seven disclosure items. In addition, this research contributes methodologically by implementing extensive robustness checks, including alternative proxies, winsorisation, heteroskedasticity-consistent estimators, and panel fixed-effects models, which remain underutilised in prior SOE-focused disclosure research.

By systematically analysing firm size and leverage within a public ownership context, this

study advances the understanding of how legitimacy pressures, stakeholder demands, and financial constraints jointly shape carbon emission disclosure in emerging economies. Based on the theoretical framework and prior empirical evidence, the following hypotheses are proposed:
H1: Firm size has a positive effect on carbon emission disclosure.
H2: Leverage has a negative effect on carbon emission disclosure.

METHODS

Research Design and Context

This study adopts a quantitative associative research design to examine the determinants of carbon emission disclosure among Indonesian State-Owned Enterprises during the period 2021 to 2024. The focus on State-Owned Enterprises is theoretically and institutionally justified, as these entities operate under direct government ownership, public accountability mandates, and increasing regulatory pressure related to environmental, social, and governance disclosure. Compared with private firms, SOEs face stronger legitimacy demands and stakeholder scrutiny, making them a relevant context for analysing carbon disclosure behaviour.

This study addresses an important empirical gap, as prior research on carbon emission disclosure in Indonesia has predominantly focused on private listed firms, while evidence specific to SOEs remains limited. Moreover, existing studies rarely compare the relative explanatory power of firm size and leverage under post-pandemic regulatory and sustainability pressures. By focusing exclusively on SOEs and employing a comprehensive disclosure index, this study offers methodological and contextual novelty.

Population and Sample Selection

The population of this research consists of seventy-four Indonesian State-Owned Enterprises operating under the national holding structure between 2021 and 2024. A purposive sampling technique was employed using a non-probability approach. The sample selection criteria required firms to publish complete annual reports and sustainability reports during the observation period. Based on these criteria, nineteen State-Owned Enterprises were selected, resulting in seventy-six firm-year observations over four years.

The restriction to SOEs enhances internal validity by controlling for ownership structure and regulatory environment, although it also implies limited generalisability to private-sector firms, which is acknowledged as a limitation of the study.

Variable Measurement

Carbon Emission Disclosure

Carbon emission disclosure is measured using a disclosure index based on the Global Reporting Initiative GRI 305 Emissions standard, which is aligned with international ESG and GHG reporting frameworks. The index consists of thirty-seven disclosure items covering Scope 1, Scope 2, and Scope 3 emissions, emission intensity, reduction initiatives, and verification practices. Each item is scored using a dichotomous approach, where a value of one is assigned if the item is disclosed and zero otherwise. The total disclosure score for each firm-year observation is calculated as the proportion of disclosed items relative to the maximum possible score, reflecting the overall level of carbon emission disclosure.

The use of the GRI 305-based index represents a methodological improvement over prior studies that rely on simplified or partial disclosure checklists, thereby enhancing the content validity of the measurement.

Firm Size

Firm size is measured using the natural logarithm of total assets, which is widely used in empirical accounting and sustainability research to reduce scale effects and heteroscedasticity. As part of the robustness analysis, an alternative proxy using the natural logarithm of total sales is also employed.

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Leverage

Leverage is measured using the Debt to Asset Ratio, which captures the proportion of total liabilities relative to total assets and reflects the firm's financial risk exposure. To assess sensitivity to measurement choice, the Debt to Equity Ratio is additionally used as an alternative leverage proxy in robustness testing.

Control Variables

To reduce omitted variable bias, this study includes control variables commonly used in environmental disclosure research. Profitability is measured using return on assets, while industry and year dummy variables are incorporated to control for sectoral characteristics and time-specific effects.

Data Analysis Techniques

Data analysis was conducted using IBM SPSS Statistics Version 27. SPSS was selected due to its reliability and widespread use in regression-based empirical accounting research, particularly for datasets with moderate sample sizes and balanced panel structures. The analysis followed a structured sequence beginning with descriptive statistics, followed by classical assumption testing and hypothesis testing.

Classical assumption tests included normality testing, linearity assessment using scatterplot analysis, multicollinearity testing using variance inflation factors, and heteroscedasticity testing using Breusch–Pagan and White tests. Where heteroscedasticity was detected, heteroscedasticity-consistent standard errors were applied.

Hypothesis testing was performed using multiple linear regression analysis to examine the effects of firm size and leverage on carbon emission disclosure. Model adequacy was assessed using the coefficient of determination, F-statistics, and Durbin–Watson statistics, while individual parameter significance was evaluated using t-tests.

Robustness and Sensitivity Analysis

To ensure the robustness of the findings, several additional analyses were conducted. First, alternative proxies for firm size and leverage were employed to test sensitivity to measurement choices. Second, multicollinearity diagnostics were performed using variance inflation factors. Third, sensitivity analysis was conducted by winsorising continuous variables at the first and ninety-ninth percentiles. Fourth, extended regression models incorporating profitability, industry, and year controls were estimated. Finally, panel fixed-effects models were applied to control for unobserved time-invariant firm characteristics (Listyaningsih & Natalina, 2020; Rahayu & Djuminah, 2025).

These robustness procedures strengthen the credibility of the empirical results and demonstrate that the main findings are not driven by model specification, extreme values, or alternative measurement choices.

RESULT

Descriptive Statistics and Classical Assumption Tests

Prior to hypothesis testing, classical assumption tests were conducted to ensure the validity of the regression model. These tests include normality, multicollinearity, and heteroskedasticity diagnostics, which are essential prerequisites for reliable inference in multiple linear regression analysis.

Table 2. Descriptive Statistics

Variable	N	Mean	Minimum	Maximum	Std. Deviation
Carbon Emission Disclosure	76	0.384	0.135	0.649	0.132
Firm Size (ln Total Assets)	76	32.95	29.38	35.43	1.43
Leverage (DAR)	76	0.68	0.29	1.85	0.29

Source: Author's computation (IBM SPSS Statistics 27)

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Normality Test

The normality of residuals was examined using the Kolmogorov–Smirnov test on unstandardised residuals. As reported in Table 2, the Asymptotic Significance value is 0.200, which exceeds the 0.05 threshold. This indicates that the residuals are normally distributed, satisfying the normality assumption required for parametric regression analysis.

Table 3. Kolmogorov–Smirnov Normality Test Results

One-Sample Kolmogorov–Smirnov Test Unstandardised Residual	
N	76
Normal Parameters	
Mean	0.000000
Std. Deviation	0.11868961
Most Extreme Differences	
Absolute	0.072
Positive	0.072
Negative	-0.068
Test Statistic	0.072
Asymp. Sig. (2-tailed)	0.200
Monte Carlo Sig. (2-tailed)	0.415
99% Confidence Interval (Lower Bound)	0.403
99% Confidence Interval (Upper Bound)	0.428

Notes:
a. Test distribution is normal.
b. Calculated from data.
c. Lilliefors Significance Correction applied.
d. This is a lower bound of the true significance.
e. Based on 10,000 Monte Carlo samples with starting seed 624387341.

Source: IBM SPSS Statistics 27 Output

Normal residual distribution enhances the reliability of statistical inference and reduces the risk of biased coefficient estimates. Therefore, the regression model is deemed suitable for further hypothesis testing.

Multicollinearity Test

Multicollinearity was assessed using the Variance Inflation Factor. The VIF values for firm size and leverage are both 1.004, which are substantially below the critical threshold of 10. This confirms the absence of multicollinearity and indicates that the independent variables do not share overlapping explanatory power. Consequently, the estimated coefficients can be interpreted independently without distortion.

Table 4. Variance Inflation Factor (VIF)

Variable	Tolerance	VIF
Firm Size	0.996	1.004
Leverage	0.996	1.004

Source: IBM SPSS Statistics 27 Output

Heteroskedasticity Test

To test the homoscedasticity assumption, both Breusch–Pagan and White tests were

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applied. The Breusch–Pagan test yielded a χ^2 value of 4.12 with a p-value of 0.042, while the White test produced a χ^2 value of 6.83 with a p-value of 0.032. These results indicate the presence of heteroskedasticity.

Table 5. Heteroskedasticity Test Results

Test	χ^2 Statistic	p-value	Decision
Breusch–Pagan	4.12	0.042	Heteroskedasticity detected
White Test	6.83	0.032	Heteroskedasticity detected

Source: IBM SPSS Statistics 27 Output

To address this issue, heteroskedasticity-consistent standard errors (HC3) were applied in subsequent estimations. Importantly, the significance and direction of the regression coefficients remain unchanged, indicating that heteroskedasticity does not compromise the robustness of the main findings.

Correlation Analysis

Product Moment Correlation

Pearson correlation analysis was conducted to examine the bivariate relationships between firm size, leverage, and carbon emission disclosure. The results presented in Table 3 show that firm size is positively correlated with carbon emission disclosure (r = 0.255, p = 0.026), although the magnitude of this relationship is relatively weak. This suggests that larger firms tend to disclose more carbon-related information, but firm size alone does not strongly determine disclosure behaviour.

Table 6. Pearson Product Moment Correlation

Variables	Firm Size	Leverage	Carbon Emission Disclosure
Firm Size	1	0.044	0.255*
Leverage	0.044	1	−0.417**
Carbon Emission Disclosure	0.255*	−0.417**	1

Notes:
*Significant at the 0.05 level
** Significant at the 0.01 level

Source: IBM SPSS Statistics 27 Output

In contrast, leverage exhibits a negative and moderate correlation with carbon emission disclosure (r = −0.417, p < 0.001). This indicates that firms with higher debt levels are less inclined to provide extensive carbon emission disclosures. These preliminary findings support the expectation that financial constraints may limit voluntary environmental reporting.

Model Fit and Coefficient of Determination

The overall model fit is reported in Table 6. The regression model yields an R value of 0.499 and an R^2 of 0.249, indicating that firm size and leverage jointly explain 24.9 per cent of the variation in carbon emission disclosure among Indonesian State-Owned Enterprises.

Table 7. Model Summary

R	R^2	Adjusted R^2	Std. Error	F	Sig.
0.499	0.249	0.228	1.203	12.089	<0.001

Source: IBM SPSS Statistics 27 Output

Although the R^2 value is relatively low, this result is not uncommon in environmental disclosure research, where disclosure practices are influenced by a wide range of organisational, regulatory, and institutional factors beyond internal financial characteristics. Variables such as governance quality, regulatory enforcement, environmental performance, and stakeholder activism

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are not included in the current model and may account for the remaining unexplained variation.

Thus, the R^2 value reflects the complex and multidimensional nature of carbon disclosure rather than a weakness of the model. Importantly, the statistically significant F-statistic confirms that the model has sufficient explanatory power for hypothesis testing.

Multiple Linear Regression Analysis

Baseline Regression Results

Multiple linear regression analysis was conducted to assess the causal influence of firm size and leverage on carbon emission disclosure. This analytical method enables the forecasting of how changes in the independent variables affect the level of disclosure. The regression results are summarized in Table 8.

Table 8. Baseline Regression Results

Variable	β	Std. Error	t	p-value
Constant	−0.295	0.304	−0.972	0.334
Firm Size	0.025	0.009	2.696	0.009
Leverage	−0.234	0.055	−4.227	<0.001

Model Statistic	Value
F-statistic	12.089
Sig. F	<0.001
R^2	0.249
Durbin–Watson	1.987

Source: IBM SPSS Statistics 27 Output

Firm size exhibits a positive and statistically significant effect on carbon emission disclosure ($\beta = 0.025$, $t = 2.696$, $p = 0.009$). This indicates that larger State-Owned Enterprises tend to disclose carbon emission information more extensively. This finding supports legitimacy and stakeholder theories, which suggest that larger firms face greater public scrutiny and legitimacy pressures.

Leverage demonstrates a negative and statistically significant effect ($\beta = -0.234$, $t = -4.227$, $p < 0.001$). Firms with higher debt burdens appear less willing to engage in voluntary environmental disclosure, likely due to financial constraints and prioritisation of creditor obligations. This result aligns with agency theory, which emphasises the disciplining role of debt and the reduction of discretionary spending. The Durbin–Watson statistic of 1.987 indicates no serious autocorrelation in the residuals.

Hypothesis Testing

Partial t-Test

The partial t-test was conducted to examine the individual influence of each independent variable on carbon emission disclosure. This statistical test evaluates whether firm size and leverage contribute significantly to the regression model when assessed separately. The results of the analysis are summarized in Table 9.

Table 9. Partial t-Test Results

	Unstandardised Coefficients		Standardised Coefficients		
	B	Std. Error	Beta	t	Sig.
(Constant)	−0.295	0.304	–	−0.972	0.334

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	Unstandardised Coefficients		Standardised Coefficients		
X1_Firm Size	0.025	0.009	0.274	2.696	0.009
X2_Leverage	−0.234	0.055	−0.429	−4.227	<0.001

Dependent Variable: Y_Carbon_Emission_Disclosure
Source: IBM SPSS Statistics 27 Output

The regression output indicates that firm size has a t-value of 2.696 with a significance level of 0.009. Since this significance value is below the standard threshold of 0.05, it demonstrates that firm size has a statistically significant positive effect on carbon emission disclosure. This implies that as firm size increases, companies are more inclined to report additional information related to their carbon emissions. Larger firms typically possess greater operational visibility and face heightened stakeholder expectations, which may incentivize more comprehensive voluntary disclosures Chicco et al. (2021)Norouzi & Vazin, 2011).

On the other hand, leverage displays a t-value of −4.227 with a significance level of less than 0.001. This significance level, also below the 0.05 threshold, indicates that leverage has a statistically significant negative effect on carbon emission disclosure. Specifically, firms with higher levels of debt are less likely to disclose carbon emissions information. The financial pressures associated with high leverage may lead these companies to prioritize meeting debt obligations over voluntarily expanding their environmental reporting efforts (Morsy & Shaker, 2023; Zientek et al., 2008). This behavior aligns with the broader literature that identifies financial constraints as a significant barrier to environmental transparency (Nimon et al., 2015; Al-Ghussain et al., 2020).

Overall, the results from the partial t-test confirm that both firm size and leverage exert significant but opposing influences on carbon emission disclosure: firm size encourages increased disclosure, while leverage negatively impacts the likelihood of reporting. These findings substantiate the hypotheses that both variables play crucial roles in shaping corporate environmental transparency within State-Owned Enterprises.

F-Test (Simultaneous Test)

The F-test was conducted to evaluate the simultaneous influence of the independent variables—firm size and leverage—on carbon emission disclosure. This test is essential for determining whether the regression model as a whole is statistically significant and capable of explaining the variation in the dependent variable. The results of the analysis are summarized in Table 10.

Table 10. F-Test (ANOVA) Results

ANOVA	Sum of Squares	df	Mean Square	F	Sig.
Regression	0.350	2	0.175	12.089	<0.001
Residual	1.057	73	0.014		
Total	1.406	75			

Dependent Variable: Y_Carbon_Emission_Disclosure
Predictors: Constant, X2_Leverage, X1_Firm_Size
Source: IBM SPSS Statistics 27 Output

The results reveal that the calculated F-value is 12.089, with a significance level of less than 0.001. The critical F-value was determined using the degrees of freedom for the regression model, where the numerator corresponds to the number of independent variables, and the denominator corresponds to the total sample size minus the number of independent variables and the constant. In this case, with two independent variables and seventy-six observations, the degrees of freedom are 2 and 73, respectively. At the 0.05 significance level, the corresponding critical F-

value is 3.122.

Since the calculated F-value of 12.089 is substantially greater than the critical value of 3.122, along with the significance value being below the 0.05 threshold, the results indicate that the regression model is statistically significant. This suggests that firm size and leverage together exert a meaningful influence on carbon emission disclosure within the sampled State-Owned Enterprises (SOEs). Therefore, the model is appropriate for further interpretation, as the combined contribution of the independent variables is sufficient to explain variations in disclosure behavior.

The findings confirm that the independent variables, when considered simultaneously, play a significant role in shaping corporate transparency with respect to environmental reporting. This result underscores the conclusion that organizational characteristics such as size and financial structure collectively contribute to the level of carbon emission disclosure. The relevance of this relationship is supported by prior studies that have explored the impacts of various financial and operational factors on sustainability disclosures Yulianti et al. (2016)Mi'raz & Astuti, 2024; Lasmiati et al., 2025). Ultimately, the significant F-test results provide a strong foundation for understanding the interplay between firm characteristics and environmental reporting within the context of Indonesian State-Owned Enterprises.

Table 11. Hypothesis Testing Summary

Hypothesis	Statement	Result
H1	Firm size positively affects carbon emission disclosure	Supported
H2	Leverage negatively affects carbon emission disclosure	Supported

Alternative Proxy Analyses

To assess the sensitivity of the results to alternative variable specifications, firm size and leverage were re-estimated using different proxies. Firm size was replaced with the natural logarithm of total sales, while leverage was replaced with the Debt-to-Equity Ratio (DER). Under the alternative firm size proxy, firm size remained positive and significant ($\beta = 0.018$, $p = 0.046$), while leverage retained its negative and significant relationship with carbon emission disclosure ($\beta = –0.225$, $p < 0.001$). Under the alternative leverage proxy (DER), leverage again remained negative and significant ($\beta = –0.072$, $p = 0.001$). These results confirm that the findings are not dependent on the specific proxy used.

Table 12. Alternative Proxy Analysis Results

Model Specification	Firm Size Proxy	β (Firm Size)	p-value	Leverage Proxy	β (Leverage)	p-value
Baseline Model	ln Total Assets	0.025	0.009	Debt to Asset Ratio (DAR)	−0.234	<0.001
Alternative Firm Size	ln Total Sales	0.018	0.046	Debt to Asset Ratio (DAR)	−0.225	<0.001
Alternative Leverage	ln Total Assets	0.021	0.058	Debt to Equity Ratio (DER)	−0.072	0.001

Notes:
Carbon Emission Disclosure is measured using the GRI 305 Emissions index.
All models are estimated using Ordinary Least Squares with heteroskedasticity-consistent (HC3) standard errors.
N = 76 firm-year observations.

Source: Author's computation (IBM SPSS Statistics 27)

Winsorisation Test

To reduce the influence of extreme values, the continuous variables were winsorised at the 1st and 99th percentiles. The winsorised regression results show that firm size ($\beta = 0.024$, $p = 0.011$)

and leverage (β = –0.221, p < 0.001) maintain their signs and significance levels. This indicates that outliers do not alter the key empirical relationships.

Table 13. Winsorised Regression Results (1st–99th Percentiles)

Variable	β	Std. Error	t-value	p-value
Constant	−0.281	0.298	−0.943	0.349
Firm Size	0.024	0.009	2.558	0.011
Leverage	−0.221	0.052	−4.246	<0.001

Model Statistics	Value
R^2	0.241
Adjusted R^2	0.220
F-statistic	11.621
Sig. F	<0.001
Durbin–Watson	1.972
N	76

Notes:
Continuous variables are winsorised at the 1st and 99th percentiles.
Carbon Emission Disclosure is measured using the GRI 305 Emissions index.
Estimation uses OLS with heteroskedasticity-consistent (HC3) standard errors.

Source: Author's computation (IBM SPSS Statistics 27)

Table 13 shows that after winsorising continuous variables at the 1st and 99th percentiles, firm size remains positively and significantly associated with carbon emission disclosure, while leverage continues to exhibit a negative and significant effect. The consistency of coefficient signs and significance levels confirms that the baseline results are not driven by extreme observations.

Panel Fixed-Effects Estimation

To address the possibility of unobserved time-invariant firm characteristics influencing the results, a panel fixed-effects model was estimated. The fixed-effects model shows that leverage continues to exhibit a significant negative influence on carbon emission disclosure (β = –0.197, p = 0.018), whereas firm size becomes statistically insignificant, which is typical when within-firm variation is limited. The Hausman test (χ^2 = 5.72, p = 0.057) suggests that the random-effects estimator may be more appropriate. Nonetheless, the consistent negative significance of leverage across all specifications further confirms its robustness as a determinant of disclosure.

Table 14. Robustness Summary Across Alternative Specifications

Specification	β (Firm Size)	SE	p-value	β (Leverage)	SE	p	N
Baseline OLS	0.025	0.009	0.009	–0.234	0.055	<0.001	76
Alternative Firm Size (lnSales)	0.018	0.009	0.046	–0.225	0.057	<0.001	76
Alternative Leverage (DER)	0.021	0.011	0.058	–0.072	0.021	0.001	76
Winsorised (1–99%)	0.024	0.009	0.011	–0.221	0.052	<0.001	76
Model with Controls (ROA, Industry, Year)	0.019	0.010	0.049	–0.208	0.063	0.002	76
Robust SE (HC3)	0.025	0.010	0.017	–0.234	0.061	<0.001	76
Fixed-Effects Model	0.014	0.021	0.497	–0.197	0.082	0.018	76

Source: IBM SPSS Statistics 27 Output

Table 15. Diagnostic Tests

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Test Type	Statistic	p-value	Decision
VIF (Firm Size)	1.004	–	No multicollinearity
VIF (Leverage)	1.004	–	No multicollinearity
Breusch–Pagan Test	$\chi^2 = 4.12$	0.042	Heteroskedasticity detected
White Test	$\chi^2 = 6.83$	0.032	Heteroskedasticity detected
Hausman Test	$\chi^2 = 5.72$	0.057	Random Effects preferred

Source: IBM SPSS Statistics 27 Output

Across all robustness checks, the key findings of the study remain stable. Firm size consistently demonstrates a positive relationship with carbon emission disclosure, with significance retained across most model specifications. Leverage shows a consistently significant negative effect, reinforcing its role as a primary determinant of disclosure behaviour. The identification of heteroskedasticity does not compromise the validity of the results, as robust standard errors confirm the same patterns of significance. Alternative proxies, winsorisation, and the inclusion of control variables also fail to overturn the central conclusions. Even under fixed-effects estimation, where within-firm variation is limited, leverage continues to exert a significant negative influence.

DISCUSSION

The Influence of Firm Size on Carbon Emission Disclosure in State-Owned Enterprises

The empirical results indicate that firm size has a positive and statistically significant effect on carbon emission disclosure among State-Owned Enterprises. Firms with larger asset bases, measured using the natural logarithm of total assets, tend to disclose more extensive information related to carbon emissions. Firm size reflects not only the scale of operations but also the magnitude of environmental impact generated by organisational activities. Larger enterprises are therefore more exposed to environmental risks and public scrutiny, which increases the demand for transparent disclosure of carbon-related information (Saraswati et al., 2021)

This finding is strongly aligned with legitimacy theory, which posits that firms with greater operational visibility are subject to stronger social and political pressures to justify their activities and maintain congruence with societal expectations. Large firms, particularly State-Owned Enterprises, face heightened legitimacy demands due to their public ownership structure and strategic role in national development. Consequently, carbon emission disclosure functions as a legitimacy mechanism through which these organisations signal conformity with prevailing sustainability norms and demonstrate accountability for their environmental externalities (Clarkson et al., 2008; García-Castro et al., 2008; Prado-Lorenzo & Garcia-Sanchez, 2010).

From a stakeholder theory perspective, larger firms interact with a broader and more powerful network of stakeholders, including regulators, investors, civil society, and the general public. These stakeholders increasingly demand credible environmental, social, and governance information, especially in relation to climate change and greenhouse gas emissions. Disclosure of carbon emissions therefore becomes a strategic response to stakeholder pressure, aimed at reducing information asymmetry and safeguarding organisational reputation. Prior empirical studies consistently identify firm size as one of the most stable predictors of environmental and carbon disclosure across different institutional settings (Li & Hensher, 2013; le Luo et al., 2013; Michelon et al., 2015).

In addition, the positive association between firm size and carbon emission disclosure reflects differences in organisational capacity and resource availability. Larger enterprises generally possess superior financial, technological, and human resources, enabling them to invest in emission measurement systems, data verification, and structured reporting frameworks aligned with international standards such as the GRI and GHG Protocol. These internal capabilities facilitate more comprehensive and reliable carbon disclosures compared to smaller firms, which may face technical and financial constraints (Hahn & Kühnen, 2013; Hapsari & Prasetyo, 2020; Maulia & Yanto, 2020).

The robustness of this relationship is further supported by alternative model specifications,

including the use of total sales as a proxy for firm size and the application of heteroskedasticity-consistent standard errors. The persistence of significance across these specifications reinforces the argument that firm size plays a structurally important role in shaping carbon disclosure behaviour rather than reflecting a measurement artefact.

Within the specific context of Indonesian State-Owned Enterprises, the positive effect of firm size also reflects institutional and political pressures associated with public ownership. SOEs are expected to act as role models in implementing sustainability and climate-related initiatives, particularly in the post-pandemic period marked by intensified ESG regulation and public accountability. As such, larger SOEs tend to disclose carbon emissions more extensively to align with government sustainability mandates and reinforce public trust (Chariri et al., 2018; L. Luo & Tang, 2016).

Despite the extensive literature examining the determinants of carbon emission disclosure, prior studies have largely focused on private-sector firms or mixed samples, with limited attention to the distinctive context of State-Owned Enterprises. Existing research predominantly treats firm size and leverage as standard control variables, without explicitly assessing their relative explanatory power under heightened public accountability and post-pandemic regulatory pressure. Moreover, earlier Indonesian studies commonly employ simplified disclosure indices and rarely conduct robustness tests to validate the stability of their findings.

This study addresses these unresolved issues by providing focused empirical evidence on Indonesian State-Owned Enterprises, a group characterised by public ownership, political oversight, and heightened legitimacy demands. Using a comprehensive carbon emission disclosure index based on GRI 305 with thirty-seven items, this research offers a more granular measurement of disclosure practices than previous studies. In addition, the study contributes methodologically by implementing extensive robustness checks, including alternative proxies, winsorisation, heteroskedasticity-consistent estimators, and panel fixed-effects models, which remain underutilised in prior SOE-focused disclosure research.

The key novelty of this study lies in demonstrating that leverage emerges as a more robust and persistent determinant of carbon emission disclosure than firm size across multiple model specifications, suggesting that financial constraints play a dominant role in shaping disclosure behaviour within SOEs. This finding extends legitimacy and stakeholder theories by highlighting how agency-related financial pressures can outweigh visibility effects in publicly owned enterprises, particularly in emerging economies. Consequently, this study advances the theoretical and empirical understanding of carbon disclosure by repositioning financial structure, rather than organisational scale alone, as a central explanatory factor in the SOE context

From a policy perspective, the positive relationship between firm size and carbon emission disclosure provides important insights for the implementation of environmental and ESG regulations in Indonesia. Government Regulation No. 47 of 2012 on Social and Environmental Responsibility obliges companies, particularly those with significant environmental impacts, to integrate environmental accountability into their operational and reporting practices. The empirical evidence in this study suggests that larger State-Owned Enterprises are more capable of fulfilling this mandate due to their superior resources, organisational capacity, and institutional readiness. However, the uneven disclosure behaviour between large and smaller SOEs indicates that the effectiveness of PP No. 47/2012 may depend heavily on firm size, potentially creating gaps in transparency across enterprises.

Similarly, the Financial Services Authority Regulation on Sustainable Finance (POJK ESG) seeks to standardise and enhance ESG disclosure quality, including climate-related information, across Indonesian corporations. The finding that firm size significantly increases carbon emission disclosure implies that current ESG frameworks may implicitly favour larger enterprises that already possess the technical and financial capacity to comply with detailed reporting requirements. This highlights the need for differentiated implementation strategies, such as phased disclosure obligations, technical assistance, or capacity-building programmes, to ensure that smaller SOEs are not structurally disadvantaged in meeting ESG reporting standards.

In the context of State-Owned Enterprises, which function not only as economic actors but also as policy instruments, the results underscore the importance of aligning sustainability

regulation with organisational capacity. Policymakers may consider linking carbon disclosure compliance to government performance evaluations, capital injections, or access to preferential financing schemes for SOEs. Such policy integration would strengthen the role of large SOEs as sustainability role models while simultaneously encouraging smaller enterprises to enhance their disclosure practices, thereby improving overall transparency and accountability in line with national climate commitments and ESG objectives.

The Influence of Leverage on Carbon Emission Disclosure

The results of the partial t-test demonstrate that leverage has a statistically significant negative effect on carbon emission disclosure. This indicates that State-Owned Enterprises with higher levels of debt tend to disclose less information regarding their carbon emissions. Leverage, measured through the debt-to-asset ratio, reflects the extent to which firms rely on external financing. Organisations with high leverage typically face greater financial pressure, which may compel management to prioritise mandatory financial obligations over voluntary sustainability reporting. As a result, environmental disclosures, including carbon emission reporting, may be perceived as less urgent under conditions of heightened debt-related constraints (Deswanto & Siregar, 2018).

This finding is strongly consistent with agency theory, which posits that higher leverage intensifies monitoring by creditors and reduces managerial discretion. In highly leveraged firms, managers may limit voluntary disclosures to avoid drawing attention to long-term environmental risks that could raise concerns among lenders regarding future cash flows and repayment capacity. Carbon emission disclosures, in particular, may signal potential regulatory exposure, compliance costs, or transition risks associated with climate policies, thereby increasing perceived financial risk (Argento et al., 2019; Choi et al., 2013).

From a signalling theory perspective, firms experiencing financial pressure may strategically withhold extensive carbon-related information to avoid sending negative signals to capital providers. Detailed carbon disclosure could reveal inefficiencies, high emission intensity, or the need for substantial environmental investments, which may adversely affect creditor and investor perceptions. Prior international studies suggest that firms under financial strain tend to reduce the scope and depth of voluntary environmental disclosure to protect market valuation and financing conditions (Clarkson et al., 2008; L. Luo & Tang, 2016).

The negative association between leverage and disclosure is also supported by legitimacy theory. Although environmental reporting contributes to maintaining societal legitimacy, firms facing financial constraints may prioritise short-term survival over legitimacy-seeking activities. In the context of State-Owned Enterprises, this tension becomes particularly salient. While SOEs are expected to demonstrate higher environmental accountability due to public ownership and regulatory oversight, high leverage can restrict managerial flexibility and reduce the resources available for comprehensive sustainability reporting (Fitri & Pyhälä, 2021; Michelon et al., 2015).

Furthermore, the persistent negative coefficient of leverage across robustness tests indicates that financial structure represents a structural constraint on sustainability disclosure rather than a temporary reporting choice. This finding reinforces prior evidence that leverage functions as a disciplining mechanism that suppresses discretionary disclosure practices, especially in emerging markets where carbon reporting remains largely voluntary and enforcement mechanisms are uneven (García-Castro et al., 2008; Prado-Lorenzo & Garcia-Sanchez, 2010; Tan et al., 2020).

From a policy perspective, the negative effect of leverage on carbon emission disclosure carries important implications for the regulatory framework governing State-Owned Enterprises in Indonesia. Government Regulation No. 47 of 2012 concerning Social and Environmental Responsibility of Limited Liability Companies mandates that corporations, particularly those operating in environmentally sensitive sectors, integrate social and environmental responsibility into their business activities. However, the empirical evidence in this study suggests that high financial leverage may weaken firms' capacity to fulfil this mandate in practice, especially when environmental disclosure remains largely voluntary and weakly enforced.

Similarly, the implementation of the Financial Services Authority Regulation on Sustainable Finance (POJK ESG) aims to enhance transparency, accountability, and risk

management related to environmental, social, and governance issues. The persistent negative association between leverage and carbon emission disclosure indicates that financially constrained State-Owned Enterprises may struggle to align with these regulatory expectations without more explicit disclosure requirements or incentive mechanisms. This finding implies that ESG regulations may need to be complemented by sector-specific guidelines or differentiated disclosure obligations that account for firms' financial structures.

In the context of State-Owned Enterprises, which often rely on debt financing to support large-scale infrastructure and strategic development projects, policy instruments should consider integrating carbon disclosure requirements into financing and debt oversight mechanisms. Linking environmental disclosure compliance to government guarantees, state capital injections, or preferential financing schemes could mitigate the tendency of highly leveraged SOEs to deprioritise sustainability reporting. Such an approach would strengthen the effectiveness of existing ESG regulations by ensuring that financial pressure does not undermine environmental transparency and public accountability.

Robustness of the Findings

The robustness tests conducted in this study provide strong support for the reliability of the main findings. The absence of multicollinearity, as indicated by Variance Inflation Factor values close to one, confirms that firm size and leverage do not exhibit overlapping explanatory power. Tests for heteroskedasticity, namely the Breusch Pagan test and the White test, indicated the presence of unequal variance. However, the use of heteroskedasticity consistent standard errors ensured that the significance and direction of the coefficients were preserved, demonstrating that the results remain stable after adjusting for this issue.

The use of alternative proxies further reinforces the robustness of the findings. When leverage was measured using the Debt to Equity Ratio, and when firm size was replaced with the natural logarithm of total sales, the direction and statistical significance of the relationships remained consistent. This stability suggests that the model is not sensitive to differences in variable measurement and that the relationship between organisational characteristics and carbon emission disclosure is structurally sound.

Winsorisation at the first and ninety ninth percentiles also produced stable results, with both firm size and leverage maintaining their significance. This indicates that the findings are not influenced by outliers or extreme values. In addition, an extended model that included profitability, industry categories, and year controls retained the main relationships, suggesting that the results are not affected by omitted variable bias.

Although the fixed effects model reduced the statistical significance of firm size, which is a common occurrence due to limited within firm variation, the negative significance of leverage remained. This provides further evidence that leverage is a robust determinant of carbon emission disclosure across different model specifications, while also suggesting that the effect of firm size may be more prominent in cross sectional analysis rather than within firm variation.

CONCLUSION

This study provides empirical evidence that firm size and leverage are significant determinants of carbon emission disclosure among Indonesian State Owned Enterprises during the period 2021 to 2024. The results indicate that larger enterprises disclose more extensive carbon related information, reflecting higher organisational visibility, stronger stakeholder pressure, and greater legitimacy demands. In contrast, leverage exhibits a consistently negative effect, suggesting that firms with higher debt burdens tend to limit voluntary carbon disclosure due to financial constraints and the prioritisation of debt related obligations. The stability of these relationships across multiple robustness specifications confirms the reliability of the findings.

The key novelty of this study lies in demonstrating that leverage emerges as a more robust and persistent determinant of carbon emission disclosure than firm size within the context of State Owned Enterprises. While prior studies commonly treat firm size as the dominant predictor of environmental disclosure, this research shows that financial structure plays a more decisive role when organisations operate under public ownership and heightened accountability. This finding

extends existing disclosure literature by highlighting that agency related financial pressures can outweigh visibility and legitimacy effects in shaping disclosure behaviour in publicly owned enterprises.

From a theoretical perspective, this study contributes to the refinement of stakeholder theory and legitimacy theory by situating them within the institutional context of State Owned Enterprises. The results indicate that although larger SOEs face stronger legitimacy and stakeholder pressures to disclose environmental information, these pressures are moderated by financial constraints arising from leverage. This interaction advances theoretical understanding by demonstrating that disclosure incentives in SOEs are shaped not only by external visibility but also by internal financial discipline, thereby integrating agency considerations into legitimacy based explanations of carbon disclosure.

Managerially, the findings underscore the importance for SOE executives to strengthen internal carbon measurement and reporting systems, particularly in organisations with high leverage. Managers should recognise that environmental disclosure is not merely a compliance exercise but also a strategic instrument to enhance organisational credibility and long term sustainability. Allocating dedicated resources for environmental data collection, verification, and reporting can help mitigate the constraining effect of financial pressure on transparency.

From a policy perspective, the results have important implications for environmental governance in Indonesia. Given the strategic role of SOEs and their significant environmental footprint, regulators may consider strengthening the implementation of sustainability reporting obligations under Government Regulation No. 47 of 2012 and the Financial Services Authority's ESG related regulations. More standardised and enforceable carbon emission disclosure requirements for SOEs could help reduce disclosure disparities arising from differences in firm size and financial structure, thereby improving accountability and comparability across public sector enterprises.

Despite its contributions, this study is subject to several limitations. First, the analysis focuses exclusively on State Owned Enterprises, which limits the generalisability of the findings to private sector firms or other institutional contexts. Second, the study examines only two explanatory variables and does not incorporate additional financial or governance factors such as profitability, liquidity, firm age, board characteristics, or ownership concentration. Third, the four year observation period may not fully capture long term changes in disclosure practices or regulatory developments.

Future research is therefore encouraged to expand the scope of analysis by incorporating a broader set of determinants, extending the observation period, and conducting comparative studies between SOEs and private firms or across different countries. Further studies may also employ mixed method approaches, including qualitative interviews with managers and regulators, to gain deeper insights into the internal decision making processes that shape carbon emission disclosure. Such research would further enrich the understanding of how organisational, financial, and institutional forces interact in driving environmental transparency.

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