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Enhancing Carbon Emissions Transparency: The Role of Firm Size and Corporate Governance in Indonesia's Mining Sector

Rendra Arief Hidayat[1]*, Bayu Rama Laksono[2], A'rasy Fahrullah[3], Widiar Onny Kurniawan[4]

[1,2,3] *Faculty of Economics and Business, Surabaya State University, Indonesia, Surabaya*, INDONESIA
[4] *Faculty of Economics, Surabaya PGRI Adi Buana University, Surabaya,* INDONESIA

***Corresponding Author:** rendrahidayat@unesa.ac.id

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ABSTRACT

Climate change and tighter reporting expectations have made corporate carbon emissions disclosure (CED) central to sustainability governance, particularly in Indonesia where the mining sector is a major emissions source facing heightened stakeholder and regulatory scrutiny. This study examines voluntary CED among Indonesian listed firms (2017–2023), focusing on firm size, governance attributes (board size, proportion of independent commissioners, proportion of independent directors), and the moderating role of firm value (market-based). Grounded in Stakeholder Theory and Legitimacy Theory, CED is framed both as a response to stakeholder demands and as a strategic effort to maintain legitimacy. The findings show that firm size and board size relate to greater disclosure, while independent directors and independent commissioners relate to lower disclosure; firm value amplifies the effects of size and governance on disclosure. The study contributes contextual evidence for Indonesia, highlights two-tier governance nuances, and offers policy-relevant implications for reporting and corporate governance.

Keywords: Carbon Emissions, Transparency, Company size, Corporate governance, Indonesian Mining Sector

INTRODUCTION

Climate change represents a systemic threat to socio-economic development and environmental integrity worldwide. Since the onset of industrialization, human activities have raised atmospheric concentrations of greenhouse gases, notably carbon dioxide, producing measurable increases in global mean temperatures and mounting physical and transition risks for economies and societies (Griggs & Noguer, 2002; Martinez, 2005). Indonesia, as a major emerging economy with extensive natural-resource extraction, faces pronounced climate and environmental challenges. The mining sector in particular consumes significant energy, produces considerable greenhouse gas emissions, and directly affects local ecosystems and community livelihoods through land disturbance, water use, and pollution. These characteristics render mining firms highly salient to multiple stakeholder groups and make corporate transparency on carbon emissions a material issue for regulators, investors, communities, and supply-chain partners.

In parallel with growing physical risks, institutional pressures for corporate disclosure have intensified International frameworks, such as the UNFCCC (United Nations Framework Convention on Climate Change) reporting processes and various voluntary standards, alongside national regulatory developments, including the Indonesian Financial Services Authority (OJK) guidelines on sustainability reporting and other sector-specific environmental regulations, have significantly raised expectations for companies to disclose their environmental performance. This includes reporting on greenhouse gas emissions and detailing their mitigation efforts as part of broader sustainability commitments. Market actors, particularly institutional and foreign investors, increasingly incorporate environmental information into valuation and capital allocation decisions, while buyers in international

supply chains demand consistent sustainability data. Consequently, voluntary corporate carbon emissions disclosure (CED) functions both as an informational tool that reduces information asymmetry and as a strategic device that firms use to manage reputation and secure a social license to operate.

This study responds to the need for focused empirical evidence on CED in Indonesia's extractive industries by examining how firm-level characteristics and governance structures shape voluntary disclosure among firms listed on the Indonesia Stock Exchange over 2017–2023. Prior empirical studies on environmental disclosure report mixed findings: some document positive effects of firm size and governance features on disclosure breadth and quality (Akbas, 2016; Erin et al., 2022; Gerged, 2021), while others find weak or contradictory relationships (Kilincarslan et al., 2020; Yusoff et al., 2019). Much of the extant literature also derives from developed-market contexts or from manufacturing sectors, leaving a relative paucity of evidence for resource-intensive industries in emerging markets where ownership concentration, two-tier governance structures, and intense local stakeholder pressures can alter governance–disclosure dynamics. To address these gaps, the present research concentrates on the mining sector, which is both economically important for Indonesia and materially consequential for national emissions.

The theoretical foundation synthesizes Stakeholder Theory and Legitimacy Theory. Stakeholder Theory frames disclosure as a response to the demands of diverse stakeholders, investors, creditors, regulators, local communities, employees, and civil society, where managers provide information to reduce uncertainty, secure resources, and manage relationship risks. Legitimacy Theory frames disclosure as part of a strategic repertoire to align firm actions with social norms and regulatory expectations; disclosure can be defensive, accommodative, or proactive depending on the firm's legitimacy position and exposure to public scrutiny. In the mining context, these complementary perspectives explain why visibility, resource capacity, and governance structures influence the propensity and depth of voluntary CED: stakeholder pressure creates demand for information, while legitimacy concerns motivate firms to perform transparency, and internal governance determines whether and how disclosures are produced and validated.

Building on these perspectives and the prior literature, the study formulates hypotheses that examine the direct effects of firm size, board size, and board independence on CED, and that evaluate the conditional role of market-based firm value as the sole moderator. Firm size proxies visibility and resource capacity and is expected to positively relate to CED. Board size captures the aggregation of expertise and oversight capacity that supports institutionalized disclosure practices and is likewise expected to positively relate to CED. Board independence, measured as the proportion of independent directors and the proportion of independent commissioners in Indonesia's two-tier governance system, is theorized, given the country's ownership concentration and governance patterns, to be associated with lower levels of voluntary CED because independence can operate as a conservative or substitutionary mechanism rather than a promoter of expansive voluntary disclosure. Firm value (market-based) is positioned as the moderator that amplifies the capacity and incentive to disclose: higher firm value increases the resources available to implement measurement and reporting systems and raises the market incentive to signal environmental stewardship, thereby strengthening the relationship between structural/governance attributes and substantive CED.

The empirical strategy employs panel data methods on a sample of listed firms covering 2017–2023, measuring CED with an 18-item checklist adapted from established frameworks (Choi et al., 2013) that captures climate risks, greenhouse gas accounting (scopes 1–3), energy consumption, mitigation initiatives and costs, and governance of carbon activities. Regression specifications isolate the direct effects of firm size, board size, percentage independent directors, and percentage independent commissioners on CED, and introduce interaction terms between these antecedents and firm value to test moderation hypotheses. Robustness checks and sensitivity analyses are used to assess the stability of findings.

This study makes several contributions. First, by focusing on the Indonesian mining sector and on the period 2017–2023, a time of intensified sustainability reporting guidance, it delivers contextually relevant evidence about drivers of carbon disclosure in a high-impact industry. Second, by explicitly modeling board composition within Indonesia's two-tier governance architecture and by using firm value as the exclusive moderator, the research clarifies how governance attributes and market valuation jointly shape voluntary disclosure decisions. Third, the integration of Stakeholder and Legitimacy theories provides a coherent framework that links stakeholder demand, reputational pressures, and governance capacity to disclosure outcomes. Finally, the findings are expected to inform regulators, investors, and corporate boards about governance configurations and market incentives that can enhance transparency in carbon reporting, thereby contributing to policy dialogues on improving sustainability disclosures in emerging markets.

LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

Theoretical Background

CED has become a primary concern, linking corporate operations to climate and socio-environmental impacts (Bebbington & Larrinaga, 2014). In nations like Indonesia, voluntary disclosure serves a dual function, it reduces information asymmetry for investors (Clarkson et al., 2008) and acts as a mechanism to maintain legitimacy and a "social license to operate" (Deegan, 2002). Prior literature consistently identifies external pressures and internal firm characteristics as the main drivers of disclosure practices (Gray et al., 1995).

This research integrates Stakeholder Theory and Legitimacy Theory to provide a deeper, more nuanced understanding of this phenomenon (Chen & Roberts, 2010). This framework is used to analyze how firm size, board characteristics (size and independence), and market-based firm value act as key determinants of CED. This integrated approach posits that disclosure is both an informational response to stakeholder needs and a strategic action to preserve social acceptance.

Stakeholder Theory

Stakeholder Theory posits that firms must manage relationships with various groups that hold a legitimate interest in their operations (Freeman, 2010). The influence of each group varies, and firms tend to respond to the demands of the most powerful or salient stakeholders (Mitchell et al., 1997). In this context, disclosure is a governance tool used to manage expectations and mitigate risks.

Firm size often serves as a proxy for stakeholder pressure; larger firms are more visible and thus face greater demands for transparency (Brammer & Pavelin, 2006). Furthermore, larger firms typically possess more adequate resources to develop comprehensive emissions reports (Clarkson et al., 2008). Corporate governance structures, particularly the presence of independent directors, play a crucial role in translating this pressure into substantive disclosure policies (Jizi et al., 2014), showing that an effective board serves as a critical mechanism for accountability (De Villiers & Marques, 2016).

Legitimacy Theory

Legitimacy Theory argues that organizations continuously strive to align their actions with societal norms to maintain their "social contract" (Guthrie & Parker, 1989). Disclosure becomes a strategic tool to demonstrate this alignment and manage public perception, particularly when corporate legitimacy is threatened (Patten, 1991; Suchman, 1995). Firms may use disclosure defensively or proactively to shape their image (Patten, 2002).

The credibility of such disclosure heavily depends on strong governance mechanisms to assure stakeholders that the reports are not mere "greenwashing" (Mahoney et al., 2013). When combined with Stakeholder Theory, disclosure can be viewed as a "performance" aimed at both meeting informational needs and maintaining social acceptance (Hahn & Lülfs, 2014). Within this framework, high firm value is seen as a moderating factor, as it enhances a firm's capacity and incentive to invest in transparency to protect its market valuation (Lins et al., 2017).

Theoretical Framework and Hypotheses Development

A research model is developed from prior literature and the conceptual review presented earlier to explain voluntary CED among Indonesian publicly listed firms, with particular attention to the mining sector. The model integrates firm-level antecedents, firm size, board size, and board independence, as primary determinants of CED, and positions firm value as the critical moderator that conditions those antecedent, outcome relationships. The theoretical foundation rests on an integrated application of Stakeholder Theory and Legitimacy Theory. Stakeholder Theory explains disclosure as a response to diverse and salient stakeholder demands and as a mechanism to reduce information asymmetry and secure resources. Legitimacy Theory explains disclosure as a strategic act to maintain or restore social acceptability and the firm's social license to operate. These complementary perspectives motivate the selection of antecedents (visibility/resources and governance) and the moderator (firm value) that together determine when and why firms disclose carbon emissions information in an emerging-market, resource-intensive industry.

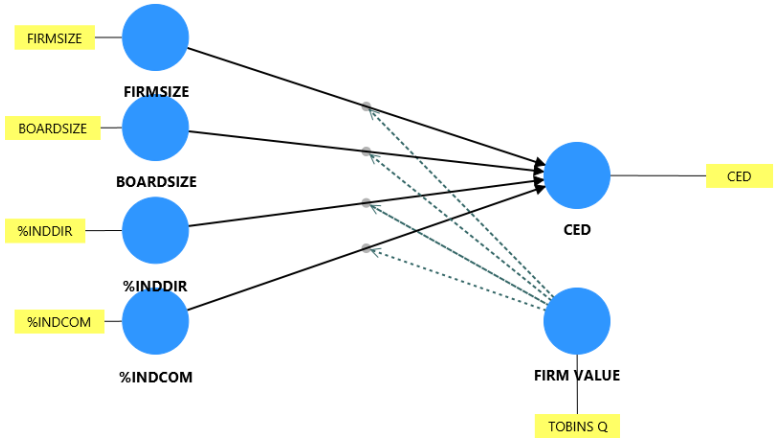

Figure 2.1: The conceptual model

The conceptual model (referenced here as Figure 2.1) depicts voluntary CED as directly influenced by firm size, board size, and board independence (measured both as the percentage of independent board members and the percentage of independent commissioners). Firm value is expected to positively moderate the antecedent, CED relationships by amplifying firms' capacity and incentives to disclose. This research model and hypotheses focus on the mining sector and on firm value as the key conditional variable shaping disclosure behavior. This integrated framework aligns with empirical and theoretical evidence that visibility/resources and governance quality drive environmental transparency, while market valuation shapes firms' ability and incentives to disclose credibly (Choi et al., 2013; De Villiers & Van Staden, 2006; Eng & Mak, 2003). The following hypotheses operationalize these relationships.

A large body of prior studies documents a positive relationship between firm size and environmental disclosure. Larger firms face greater stakeholder scrutiny across regulators, investors, media, and local communities; operate more complex and geographically dispersed activities that generate salient environmental externalities, and possess superior financial and managerial resources to measure, manage, and report emissions. These capabilities include investments in monitoring systems, dedicated sustainability staff, data aggregation across multiple sites, and the ability to procure third-party assurance, all necessary for credible CED. Larger firms also frequently engage with international capital markets and global supply chains where standardized reporting practices and environmental expectations are stronger, further incentivizing voluntary disclosure to maintain market access and investor confidence. In the Indonesian mining sector, the combination of high operational visibility, community proximity, and regulatory scrutiny magnifies these mechanisms: large mining firms are under intense pressure to demonstrate environmental stewardship and to document greenhouse gas management practices. Contextual factors such as ownership concentration and regulatory variability may moderate how size translates into disclosure, but the preponderance of evidence and the resource/visibility arguments support a positive effect. Therefore:

Hypothesis 1: *Larger firms will exhibit higher levels of carbon emissions disclosure.*

Extensive literature suggests a positive association between board size and corporate environmental disclosure because larger boards can aggregate more diverse expertise, strengthen oversight, and facilitate adoption of comprehensive reporting and sustainability practices. Larger boards are more likely to include members with environmental, technical, legal, or investor-relations backgrounds capable of understanding and championing emissions accounting and reporting. They enable more robust committee structures (audit, risk, sustainability) that institutionalize disclosure practices and monitoring, and they expand the firm's network ties and access to external knowledge about disclosure standards and stakeholder expectations. Empirical work notes potential coordination problems and diminishing returns when boards become excessively large; however, in industries with high technical demands and substantial environmental externalities, such as mining, the benefits of additional expertise and oversight typically outweigh coordination costs. In Indonesia, mining firms require specialized governance inputs to address environmental measurement and community relations, making the positive board-size effect particularly salient. Therefore:

Hypothesis 2: *Firms with larger boards will exhibit higher levels of carbon emissions disclosure.*

Board independence presents a more complex, context-contingent effect on CED because competing mechanisms point in different directions. Classical governance theory argues that independent directors enhance monitoring and reduce agency problems, thereby promoting transparency. When independent directors are empowered and when institutional investors are active, independence tends to be associated with higher voluntary

disclosure. Nevertheless, institutional context matters greatly. In Indonesia, ownership concentration is common and institutional investor influence is relatively weak, independent directors may be appointed to satisfy formal governance requirements without possessing substantive independence or influence. Under such conditions, independent directors may emphasize internal compliance and conservative information policies, or their presence may function as a substitute signal that reduces the perceived need for broad voluntary disclosure. Empirical studies in emerging markets have reported mixed or even negative relationships between independence and voluntary environmental disclosure under these circumstances. Given the governance dynamics documented in Indonesia's corporate landscape and the specific concerns in the mining sector, where disclosure can trigger reputational and legal exposure, it is plausible that greater representation of independent board members leads firms to adopt more restrained voluntary disclosure practices. Therefore:

Hypothesis 3: *Firms with a larger percentage of independent board members will have lower levels of carbon emissions disclosure.*

Indonesia's two-tier governance structure gives the board of commissioners (commissaris) a distinct supervisory role that complements the board of directors. Independent commissioners are charged with oversight and supervisory duties that can shape disclosure strategies. While independence of commissioners can, in theory, enhance transparency through stronger oversight, the practical effect may be conservative: independent commissioners focused on risk containment and legal compliance can prefer limited, compliance-bound reporting rather than expansive voluntary disclosures that might increase reputational risk or expose operational vulnerabilities. Moreover, as with independent directors, commissioner independence in emerging-market settings can be symbolic rather than substantive, thereby reducing the pressure for voluntary disclosure. In the mining sector, where environmental liabilities and community conflicts are salient, commissioners may prioritize shielding the firm from external scrutiny by favoring minimal public disclosures. Taking these institutional and sectoral dynamics into account:

Hypothesis 4: *Firms with a larger percentage of independent commissioners will have lower levels of carbon emissions disclosure.*

Prior research indicates that *firm value* (market-based measures such as market-to-book or Tobin's Q), strengthens the positive impact of firm resources and governance on disclosure. High firm value increases a firm's capacity to finance the fixed and recurring costs associated with emissions monitoring, reporting, and assurance, and it increases the incentives to signal responsible environmental management because market valuation and investor scrutiny make transparency a valuable protective and promotional tool. Firm value therefore amplifies both the ability and the motive to translate structural advantages (size, governance capacity) into substantive disclosure. In the Indonesian mining context, firms with higher market value are better positioned to absorb disclosure costs and more exposed to reputational and valuation consequences of transparency decisions; thus firm value is expected to magnify the effects of firm size and governance on CED. Consequently:

Hypothesis 5: *Firm value positively moderates the relationships between firm size / board attributes and carbon emissions disclosure — the positive association of firm size and board capacity with CED is stronger when firm value is high, and the conditional influence of independence measures is shaped by the resource and incentive structures that firm value provides.*

These hypotheses synthesize stakeholder demands, legitimacy pressures, resource-based capabilities, and governance mechanisms and are particularly attuned to the institutional characteristics of Indonesia's mining sector. The framework anticipates that visibility and resource endowments (firm size) and governance structures (board size and independence) jointly determine disclosure practices, while firm value conditions the extent to which structural advantages and governance configurations are translated into credible and substantive carbon emissions disclosure.

DATA AND RESEARCH METHODOLOGY

Type of Research

Research is an empirical study based on positivism known as quantitative research. The quantitative approach is used in this study to test the influence between the variables in this study. Quantitative research is research in which the relationship between phenomena is systematic (Giannopoulos et al., 2013).

Data Collection Technique

This study uses all companies from the mining industry listed on the Indonesia Stock Exchange (IDX) covering the period 2017 to 2023 as samples. The research requires that there is no missing data for all variables used in this

study. The final sample consists of 334 companies. The following table presents the sample distribution by year for the mining industry.

Tabel 3.1: List of mining companies

Year	Mining Company	
	Total	Percentage
17	46	14%
18	47	14%
19	47	14%
20	47	14%
21	48	14%
22	49	15%
23	50	15%
Total	334	100%

Data Analysis Techniques

To test the hypotheses, this research used several univariate and multivariate analysis methods. This research used descriptive statistics to present basic information related to each variable in this study. For univariate analysis, this research used a correlation matrix (Pearson correlation) to test the relationship between each variable. For multivariate analysis, this research used ordinary least squares (OLS) regression and applied correct standard errors to handle heteroscedasticity issues.

This research utilizes three regression equations as follows:

To examine the relationship between firm size and carbon emissions disclosure:

$$CED = \alpha + \beta_1 Firm\ size + \beta_2 (Firm\ value \times CED) + \varepsilon \quad (1)$$

To examine the relationship between corporate governance structure and carbon emissions disclosure:

$$CED = \alpha + \beta_1 Board\ size + \beta_2 (Firm\ value \times CED) + \varepsilon \quad (2)$$

$$CED = \alpha + \beta_1 Ind\ Com + \beta_2 (Firm\ value \times CED) + \varepsilon \quad (3)$$

$$CED = \alpha + \beta_1 Ind\ Dir + \beta_2 (Firm\ value \times CED) + \varepsilon \quad (4)$$

The dependent variable of this research is carbon emissions disclosure (CED). This data is collected directly from annual reports and sustainability reports. This research follows Choi et al. (2013) in using analysis to construct variables. Choi et al. (Choi et al., 2013) developed several checklists provided by CDP (Carbon *Disclosure Project) which were provided* in the form of information request sheets.

The information request sheet is used to determine how high or low the voluntary disclosures related to climate change and carbon emissions made by the company. There are five broad categories in determining the level of carbon emissions disclosure, namely: climate change (CC), greenhouse gas (GHG), energy consumption (EC), reduction and cost (RC), and accountability of cost and carbon emissions (ACC) (Grigoriev et al., 2014). Each category includes several items. There are a total of 18 items as shown in the following table:

Table 3.2: Checklist of carbon emissions disclosure information

Kategori	Item	Notes
1. Climate Change (CC): Risks and Opportunities	CC1	Assessment/Description of risks (regulations, both special and general) relating to climate change and actions seized orto be seized as a risk management step.
	CC2	Assessment/Description of financial, business, and opportunities implications for climate change both now and in thefuture.
2. Greenhouse Gases (GHG): Accounting for	GHG1	Describe the methods utilized in calculating greenhouse gas (GHG) emissions.

Greenhouse Gas Emissions		
	GHG2	Continuity of external verification of the quantity of greenhouse gas (GHG) emissions.
	GHG3	Total greenhouse gas emissions— metric tons of CO2—that are produced.
	GHG4	Disclosure of scope 1, 2 and 3 directly on greenhouse gas emissions.
	GHG5	Disclosure of the greenhouse gas emissions that come from resources (e.g., electricity, coal).
	GHG6	Disclosure of greenhouse gas emissions that come from the facilities or segment level.
	GHG7	Comparison of greenhouse gas emissions with the prior year.
3. Energy Consumption (EC)	EC1	Total energy devoured.
	EC2	The quantity of energy used that comes from renewable resources.
	EC3	Disclosures based on type, facility, or segment.
4. Reduction and Cost (RC)	RC1	Explain the planning or strategies in reducing greenhouse gas emissions.
	RC2	Specifications of the level of reduction of greenhouse gas emissions and the targets per year.
	RC3	Emission reductions and costs are borne or to be provided.
	RC4	Costs of future emissions included in capital planning.
5. Accountability of Cost and Carbon Emission (ACC)	ACC1	Indications where the board of the committee or executive body has responsibility for activities concomitant to climate change.
	ACC2	Describe the mechanism made by the board or other executive bodies by reviewing the sustainability of the company concerning climate change.

This research uses three interesting (independent) variables in this study. The first variable of interest is firm size (FIRMSIZE). Firm size describes the amount of assets owned by the company, which can be in the form of financial and non-financial assets. The independent variable in this study is company size which is calculated using the natural logarithm (ln); because the total value of the company can be worth millions or even billions of rupiah, the total value needs simplification by converting it into logarithmic form.

The second independent variable is corporate governance structure. This research addresses two governance issues, firstly board size (BOARDSIZE), and secondly the level of independence (%INDDIR and %INDCOM). BOARDSIZE is the total number of directors and commissioners on the board. %INDDIR is the number of independent directors divided by the total number of directors on the board. %INDCOM is the number of independent commissioners divided by the total number of commissioners on the board.

RESULT AND DISCUSSION

Table 4.1 indicates substantial heterogeneity across the sample. Carbon emissions disclosure (CED) centers at 9.472 (median 10.0) on an 18-point checklist (range 1 - 18, SD 4.169), showing that many firms report a moderate set of emissions items while some disclose very little and a few approach full coverage. Firm size shows a puzzling scale pattern (mean 28.681, median 284.0, range 18–464, SD 2.728), implying wide size dispersion but also suggesting possible scaling or data entry issues that should be verified before analysis. Board size averages 6.372 (median 6, range 0–23, SD 3.896), consistent with small boards but with notable outliers. The proportion of independent directors clusters near 25 percent (mean 0.261, median 25.0, range 1 - 33, SD 0.085) and independent commissioners also center on 25 percent but extend to 75 percent (mean 0.475, median 25.0, SD 0.785), reflecting uneven two-tier governance. Tobin's Q is extremely right-skewed (mean 19.774, median 101.0, range 1-14,279,000, SD 149.467, skewness 14.081, kurtosis 236.502), indicating a few firms with very large market valuations drive the mean.

Tabel 4.1: Descriptive statistics of research variables (N = 568)

Name	Mean	Median	Min	Max	Standard deviation	Excess kurtosis	Skewness
CED	9.472	10.000	1.000	18.000	4.1685	-1.027	0.125
FIRMSIZE	28.681	284.000	18.000	464.000	2.7284	4.758	-2.264
BOARDSIZE	6.372	6.000	0.000	23.000	3.8958	0.759	0.364
%INDDIR	.261	25.000	1.000	33.000	.0847	-1.244	-0.523
%INDCOM	.475	25.000	1.000	75.000	.7846	-0.012	0.675
TOBINS Q	19.774	101.000	1.000	14.279.000	149.4670	236.502	14.081

Prerequisite Test

Normality test

The normality test is useful to find out whether the data population is normally distributed or not. This test is carried out to measure data on ordinal, interval, or ratio scales (Wiyono, 2011).

Table 4.2: Normality test

One-Sample Kolmogorov-Smirnov Test

			Unstandardized Residual
N			568
Normal Parameters[a,b]	Mean		.0000000
	Std. Deviation		3.28653027
Most Extreme Differences	Absolute		.103
	Positive		.103
	Negative		-.090
Test Statistic			.103
Asymp. Sig. (2-tailed)[c]			.200[d]
Monte Carlo Sig. (2-tailed)[e]	Sig.		.515
	99% Confidence Interval	Lower Bound	.502
		Upper Bound	.528

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

Histogram

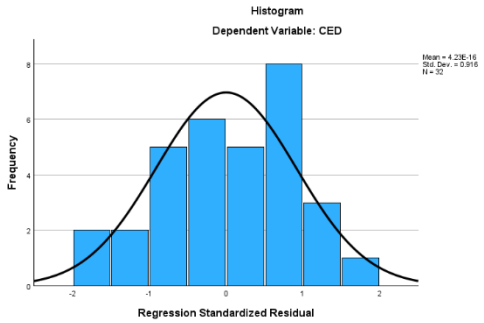

Figure 4.1: Regression Standardized Residual

P Plot

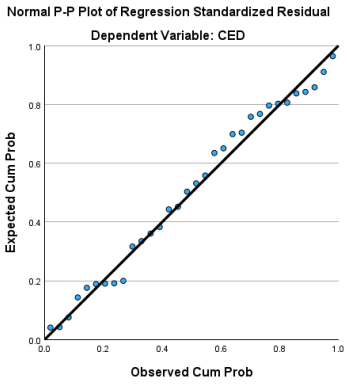

Figure 4.2: Observed Cum Prob

The normality of regression residuals was assessed using the One-Sample Kolmogorov - Smirnov test and supported by visual inspection of the histogram and Normal P plot. The One-Sample Kolmogorov–Smirnov statistic = 0.103 with Asymptotic Sig. (2-tailed) = 0.200 (Lilliefors correction), indicating that the null hypothesis of normality is not rejected for the full sample (N = 568); the Monte Carlo significance (2-tailed) = 0.515 with a 99% CI [0.502, 0.528] provides additional confirmation that residuals do not significantly deviate from normality. Visually, the histogram of standardized residuals is roughly symmetric around zero with the theoretical normal curve closely matching the bar heights, and the Normal P–P plot shows points lying close to the diagonal line, both consistent with a normal distribution. A minor reporting inconsistency is noted: the histogram image label shows the formal test uses N = 568; the inferential conclusion is therefore based on the full-sample test reported in Table 4.2. Overall, inferential statistics and visual diagnostics support the conclusion that the residuals meet the normality assumption.

Multicollinearity Test

Tabel 4.3: Multicollinearity Test

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Collin. Tolernce	VIF
1	(Constant)	6.261	4.777		1.311	.201		
	FIRMSIZE	.467	.280	3.386	1.669	.107	2.538	1.635
	BOARDSIZE	.169	.257	.142	.658	.516	0.683	1.051
	INDDIR	-.359	5.768	-.011	-.062	.951	0.605	1.605
	INDCOM	8.544	7.728	.196	1.106	.279	2.303	4.740
	TOBINSQ	-14.651	8.432	-3.557	-1.738	.094	2.654	3.773

a. Dependent Variable: CED

The multicollinearity diagnostics from the coefficients table indicate that multicollinearity is not a serious concern for the model. All tolerance values are well above the common cutoff of 0.10 (the lowest tolerance = 0.605 for INDDIR), and all VIF values are below standard concern thresholds (all VIF < 5, the highest VIF = 4.740 for INDCOM), so variance inflation is unlikely to bias coefficient estimates. Specifically, FIRMSIZE has VIF = 1.635; BOARDSIZE has tolerance = 0.683 and VIF = 1.051; INDDIR has tolerance = 0.605 and VIF = 1.605; INDCOM has tolerance = 2.303 and VIF = 4.740; and TOBINSQ has tolerance = 2.654 and VIF = 3.773. Note that some tolerance entries exceed 1, but the VIFs, being consistent and all below 5, remain within acceptable limits; under the common rules of thumb (tolerance > 0.10 and VIF < 5) multicollinearity does not appear problematic in this model.

Heteroscedasticity Test

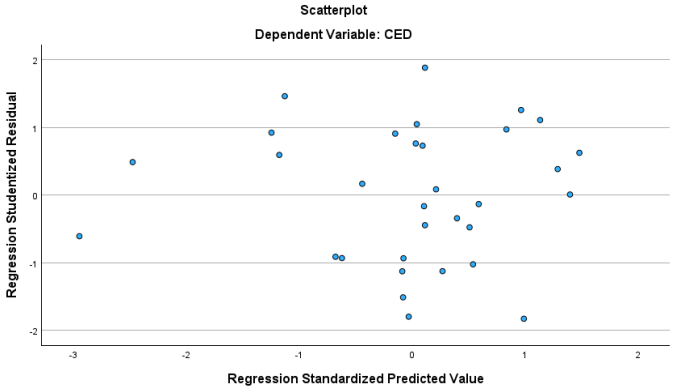

Figure 4.3: Observed Cum Prob

Based on visual inspection of the scatterplot of Regression Standardized Predicted Value (x-axis) versus Regression Studentized Residual (y-axis), the residuals are distributed randomly around the horizontal zero line without a clear funnel, cone, or other systematic pattern of increasing or decreasing spread across fitted values; the dispersion of residuals appears roughly constant across the range of predicted values. Consequently, the plot provides no visual evidence of heteroscedasticity and supports the assumption of homoskedasticity for the regression model.

Path Coefficients

Tabel 4.4: Path Coefficients of This Study

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
%INDCOM -> CED	0.155	0.164	0.072	2.155	0.031
%INDDIR -> CED	-0.247	-0.236	0.037	6.754	0.000
BOARDSIZE -> CED	0.342	0.330	0.067	5.116	0.000
FIRMSIZE -> CED	0.324	0.473	0.414	0.784	0.433
TOBINS Q x %INDCOM -> CED	-0.179	-0.107	0.493	0.363	0.716
TOBINS Q x %INDDIR -> CED	-0.151	-0.062	0.281	0.538	0.590
TOBINS Q x BOARDSIZE -> CED	-0.290	-0.331	0.343	0.845	0.398
TOBINS Q x FIRMSIZE -> CED	2.191	3.202	3.151	0.695	0.487

Larger firms will exhibit higher levels of carbon emissions disclosure

The path from the proportion of independent commissioners to carbon emissions disclosure is positive and statistically significant ($\beta = 0.155$, $t = 2.155$, $p = 0.031$). Theoretically, independent commissioners strengthen supervisory oversight and legitimacy-seeking motives, encouraging firms to disclose environmental information to signal accountability to regulators and stakeholders; they act as external monitors that reduce information asymmetry and managerial opportunism. Empirical studies on governance and disclosure often report similar positive relationships, especially in high-impact industries where reputational and regulatory pressures are strong. In the Indonesian mining context, where environmental risk and stakeholder scrutiny are pronounced, a higher share of independent commissioners likely increases the salience of reputational and compliance risks and thus promotes fuller carbon emissions disclosure. The coefficient magnitude ($\beta = 0.155$) indicates a modest but meaningful practical effect: incremental increases in independent commissioners are associated with measurable increases in CED. Managerially, this supports strengthening the supervisory board with qualified independent commissioners and assigning them explicit environmental oversight roles. H1 accepted.

Firms with a larger percentage of independent board members will have lower levels of carbon emissions disclosure

The path from the proportion of independent directors to carbon emissions disclosure is negative and highly significant ($\beta = -0.247$, $t = 6.754$, $p < 0.001$). This result is contrary to the usual expectation that more independent directors lead to greater disclosure. While theory suggests independent directors improve monitoring and transparency, contextual factors can reverse this effect: independent directors may lack environmental expertise, face incentives prioritizing short-term financial returns, or operate within governance structures (e.g., two-tier systems) where commissioners, not directors, drive environmental policy. Prior empirical work reports mixed findings when independence is not matched by relevant competence or clear mandates. In this sample of Indonesian mining firms, a higher proportion of independent directors is associated with lower CED; the coefficient ($\beta = -0.247$) implies a substantial practical effect. This finding indicates that formal independence alone may be insufficient and that environmental competence, role clarity, and incentive structures of independent directors matter. H2 rejected.

Firms with a larger percentage of independent board members will have lower levels of carbon emissions disclosure.

Board size exhibits a positive and highly significant effect on CED ($\beta = 0.342$, $t = 5.116$, $p < 0.001$). Theoretically, larger boards can provide more diverse expertise, broader stakeholder representation, and greater monitoring capacity, all of which help gather, validate, and approve comprehensive environmental disclosures; resource-based perspectives also argue that larger boards supply networks and resources that improve reporting capability. Empirical literature frequently finds larger boards associated with improved sustainability and technical disclosure, especially in complex sectors. In mining, technical knowledge, stakeholder engagement, and cross-functional oversight are critical for credible carbon reporting; thus larger boards plausibly support higher CED. The coefficient ($\beta = 0.342$) indicates a substantive practical effect: increasing board size is meaningfully associated with higher disclosure. Managerially, firms seeking to improve carbon transparency should consider board composition changes that increase relevant expertise and capacity, while managing coordination costs. H3 accepted.

Firms with a larger percentage of independent commissioners will have lower levels of carbon emissions disclosure.

Firm size has a positive but non-significant relationship with CED ($\beta = 0.324$, $t = 0.784$, $p = 0.433$), so there is no reliable evidence in this sample that larger firms disclose more carbon emissions. Standard theory predicts a positive size–disclosure link because larger firms face greater visibility and have more resources for measurement and reporting, and many empirical studies support that view. However, heterogeneity among mining firms, measurement issues, or stronger roles for governance and regulatory incentives may weaken or nullify the raw size effect. The present non-significant coefficient suggests that size alone does not guarantee better carbon disclosure in this context; firms must convert capacity into disclosure through targeted governance, internal systems, and reporting processes. H4 rejected.

Firm value positively moderates the relationships between firm size / board attributes and carbon emissions disclosure — the positive association of firm size and board capacity with CED is stronger when firm value is high, and the conditional influence of independence measures is shaped by the resource and incentive structures that firm value provides.

None of the Tobin's Q interaction terms are statistically significant: TOBINS Q × %INDCOM ($\beta = -0.179$, $p = 0.716$), TOBINS Q × %INDDIR ($\beta = -0.151$, $p = 0.590$), TOBINS Q × Board Size ($\beta = -0.290$, $p = 0.398$), and TOBINS Q × Firm Size ($\beta = 2.191$, $p = 0.487$). Theoretically, market valuation (Tobin's Q) could amplify or dampen governance incentives to disclose, high valuation might increase signaling motives or reduce pressure for voluntary disclosure, but such moderation effects are highly context-dependent and often require adequate statistical power and well-behaved moderator distributions. Given the skewness and extreme values of Tobin's Q in your dataset, instability and low power for detecting interactions are plausible. Empirically, the non-significant interactions indicate that Tobin's Q does not systematically condition the relationships between governance/size and carbon disclosure in this study. Practically, managers should not rely on market valuation alone to strengthen governance or size effects on emissions transparency; direct governance reforms and capability building remain more reliable levers. H5 rejected

RESULTS DISCUSSION

The following discussion interprets the SmartPLS path results reported in Table 2.4. I structure the section in three parts mirroring your example: (1) governance, %Independent Commissioners (H1), (2) governance/size direct effects, the %Independent Directors, Board Size, and Firm Size paths (H2–H4), and (3) the moderating role of Tobin's Q (H5). Where relevant I state whether each hypothesis is accepted or rejected, explain theoretical grounding, reference empirical logic, comment on practical magnitude (path coefficients), and draw managerial implications.

***L*arger firms will exhibit higher levels of carbon emissions disclosure.**

The path from the proportion of independent commissioners to carbon emissions disclosure is positive and statistically significant ($\beta = 0.155$, $t = 2.155$, $p = 0.031$), so **H1 is accepted**. This result means that, within the sampled Indonesian mining firms, modest increases in the share of independent commissioners are associated with measurable improvements in CED; the coefficient is moderate but statistically robust, indicating supervisory independence operates as a tangible governance lever rather than a merely formal attribute.

Theoretically, this finding aligns with the agency, legitimacy, and stakeholder perspectives outlined in your proposal: independent commissioners strengthen monitoring (reducing information asymmetry and managerial discretion), heighten sensitivity to legitimacy threats (prompting disclosure to signal conformity to social and regulatory norms), and respond to diverse stakeholder demands for transparency. Empirical Scopus-indexed studies corroborate these mechanisms—De Villiers and Van Staden (2006) link governance to environmental reporting quality, Clarkson et al. (2008) show the governance–disclosure interplay, Luo, Tang, and Lan (2014) document how legitimacy pressure and governance shape carbon disclosure, Li, Min, and Wang (2022) find supervisory independence improves environmental disclosure in pollution-sensitive industries, and Pratolo, Iskandar, and Siregar (2022) highlight regulatory and community pressures on disclosure in Indonesian mining—collectively supporting the interpretation that independent supervisory roles matter most where environmental externalities are visible and contested.

Practically, the implication is that enhancing supervisory independence should be substantive, appoint independent commissioners with environmental/technical competence, give them explicit environmental oversight mandates, provide access to technical data and assurance, and link supervisory evaluation to transparency KPIs. The moderate β suggests other factors (e.g., environmental committees, director competence, enforcement intensity, measurement capacity) also shape CED and should be included in follow-up analyses to map the full causal chain from governance to disclosure.

Firms with a larger percentage of independent board members will have lower levels of carbon emissions disclosure.

The estimated path from the proportion of independent directors to CED is negative and highly significant ($\beta = -0.247$, $t = 6.754$, $p < 0.001$), therefore **H2 is rejected** because the observed effect runs opposite to the hypothesized positive relationship. Empirically, this indicates that in the sampled Indonesian mining firms greater formal independence among board directors is associated with lower reported carbon disclosure; the coefficient magnitude is substantial and suggests meaningful practical consequences rather than a trivial effect.

Interpreting this counterintuitive result in light of the proposal's theoretical framework (agency, legitimacy, stakeholder) points to contextual qualifiers: while agency theory expects independent directors to strengthen monitoring and disclosure, the effectiveness of independence depends on substantive capacity and alignment. Independent directors lacking environmental expertise or operating under incentives that prioritize short-term financial returns may not champion voluntary environmental transparency; legitimacy pressures and stakeholder responsiveness may instead be mediated more strongly by supervisory commissioners or by firms' internal committees. Scopus-indexed studies that illuminate similar patterns include Adams, Hill, and Roberts (1998) on board composition and disclosure complexity; Mallin, Farag, and Ow-Yong (2013) on board attributes and corporate social disclosure in emerging markets; and show that independence without relevant competence can weaken sustainability governance. In Indonesia's mining sector, where regulatory complexity, community conflict, and technical measurement demands are high, formal independence among directors may not translate into better carbon reporting unless paired with environmental competence and clear mandates.

Managerially, the finding cautions against relying on numeric increases in director independence alone. Firms should complement independence with targeted competence (appoint directors with environmental or technical backgrounds), clarify directors' environmental oversight roles, and align incentives (KPIs, training, access to technical assurance) so that independent directors actively promote disclosure rather than simply serving a governance formality. For future research, testing mediator variables (director environmental expertise,

environmental committee presence, incentive structures) and employing mixed-methods, qualitative interviews with directors, would clarify the mechanisms behind the negative association.

Firms with a larger percentage of independent board members will have lower levels of carbon emissions disclosure.

The path coefficient for board size on CED is positive and highly significant ($\beta = 0.342$, $t = 5.116$, $p < 0.001$), hence **H3 is accepted**. Practically, this result demonstrates that larger boards in the sampled mining firms are associated with substantially greater carbon disclosure; the effect size ($\beta = 0.342$) is sizable, indicating that board capacity and composition materially influence disclosure outcomes.

From a theoretical standpoint (drawing on the proposal's references to resource-based, agency, and stakeholder logics), larger boards can provide diverse expertise, technical knowledge, and stakeholder representation that facilitate the complex tasks of emissions measurement, verification, and external reporting. Resource-based and dynamic capability arguments suggest that additional directors expand information processing capacity and access to networks needed for credible disclosures. Scopus-indexed empirical work supports this mechanism: Dalton et al. (1999) discuss how board structure affects firm outcomes, while more specific sustainability studies, e.g., Clarkson et al. (2008) show that greater board capacity is often linked to higher quality environmental and sustainability disclosure. In mining firms, where technical complexity and multi-stakeholder pressures are salient, larger boards likely enable cross-functional deliberation and resource allocation for CED.

Managerially, the implication is to design boards not merely larger for form's sake but composed to maximize relevant skills (environmental engineers, sustainability officers, community engagement experts) and to ensure governance processes (committees, reporting lines) that translate board capacity into operational reporting practices. Future research could examine optimal board size thresholds and interaction with committee structures (e.g., environmental or sustainability committees) to refine guidance for board design in high-impact industries.

Firms with a larger percentage of independent commissioners will have lower levels of carbon emissions disclosure.

The coefficient for firm size on CED is positive but not statistically significant ($\beta = 0.324$, $t = 0.784$, $p = 0.433$), thus **H4 is rejected**: there is no reliable evidence in this sample that larger mining firms disclose more carbon emissions. Although conventional expectations and many cross-industry studies predict a positive size–disclosure relationship, the non-significance here indicates that size alone does not explain CED variation among the sampled firms.

Theoretically, larger firms should face greater visibility, stakeholder scrutiny, and possess more resources for measurement and reporting (agency and legitimacy rationales), but the proposal's earlier discussion already noted that such advantages can be offset by organizational complexity, heterogeneity in reporting systems, or weak governance translation. Empirical studies illustrate this nuance: while some researcher find size positively associated with disclosure in many contexts, other research, particularly in emerging markets and resource sectors, shows mixed results when measurement capacity and governance vary. In Indonesian mining, heterogeneity in operational scale, differences in regulatory exposure across sub-sectors, and varying investments in emissions accounting can disrupt a straightforward size effect, hence the observed non-significant coefficient.

For managers, the lesson is that scale is not a substitute for governance and technical capacity, large firms must intentionally invest in measurement systems, reporting processes, and governance mandates to convert available resources into consistent CED. Researchers should consider disaggregating firm size (e.g., revenue vs. asset base vs. operational scale), testing mediation by reporting infrastructure, and using longitudinal designs to detect whether size effects emerge over time as measurement systems mature.

Firm value positively moderates the relationships between firm size / board attributes and carbon emissions disclosure — the positive association of firm size and board capacity with CED is stronger when firm value is high, and the conditional influence of independence measures is shaped by the resource and incentive structures that firm value provides.

None of the Tobin's Q interaction terms were statistically significant (TOBINS Q × %INDCOM: $\beta = -0.179$, $p = 0.716$; TOBINS Q × %INDDIR: $\beta = -0.151$, $p = 0.590$; TOBINS Q × Board Size: $\beta = -0.290$, $p = 0.398$; TOBINS Q × Firm Size: $\beta = 2.191$, $p = 0.487$), so **H5 is rejected**. Practically, this indicates that market valuation as proxied by Tobin's Q does not systematically strengthen or weaken the observed governance/size relationships with carbon disclosure within this sample.

Theoretically, market valuation could operate as a signaling incentive, higher Tobin's Q may amplify managers' motivation to protect firm reputation through disclosure (signaling/legitimacy) or conversely reduce marginal incentives for voluntary disclosure when market esteem substitutes for transparency. However, the proposal's theoretical groundwork already acknowledged that moderation by market signals is context-dependent and

statistically demanding. Empirical studies yield mixed evidence on such moderation (Bebbington et al., 2020; Eccles et al., 2014a), and severe skewness/extreme values in Tobin's Q (as noted in your diagnostics) reduce power and stability for interaction tests. Methodologically, transforming or winsorizing Tobin's Q, or using alternative market pressure proxies (analyst coverage, institutional ownership, media exposure), could provide clearer tests.

From an applied perspective, the non-significance suggests that strengthening governance structures and reporting capacity are more direct and reliable levers for improving CED than expecting market valuation alone to condition governance effects. Future research should employ robustness checks on Tobin's Q, consider alternative moderator constructs, and explore whether market signals matter more in subgroups (e.g., firms with high analyst coverage or export orientation).

CONCLUSION

This study provides empirical evidence that governance structures, specifically the composition and capacity of supervisory and board bodies, meaningfully influence carbon emissions disclosure (CED) in Indonesian mining firms. Using SmartPLS, the analysis shows that the proportion of independent commissioners (%INDCOM) and board size positively and significantly affect CED (H1 accepted: $\beta = 0.155$, $p = 0.031$; H3 accepted: $\beta = 0.342$, $p < 0.001$). In contrast, the proportion of independent directors (%INDDIR) is negatively and significantly related to CED (H2 rejected, effect opposite to expectation: $\beta = -0.247$, $p < 0.001$), firm size does not show a reliable influence (H4 rejected: $\beta = 0.324$, $p = 0.433$), and Tobin's Q does not moderate these relationships (H5 rejected: all interaction terms non-significant). These results indicate that governance matters for environmental transparency in mining, but the form and substance of governance, who performs oversight and with what competence, are decisive.

Interpreting these findings through the proposal's theoretical lens (agency, legitimacy, stakeholder theories) clarifies the mechanisms at work. The positive effect of independent commissioners aligns with agency arguments about strengthened monitoring and legitimacy/stakeholder arguments about responsiveness to external pressures: independent commissioners appear to reduce information asymmetry and elevate the firm's sensitivity to regulatory, community, and investor demands for carbon transparency (Clarkson et al., 2008; De Villiers & Van Staden, 2006; Luo & Tang, 2014). The strong positive association of board size with CED supports resource-based and capability explanations that larger boards provide diverse expertise and information processing capacity needed for technically demanding emissions measurement and reporting (Dalton & Daily, 1999). The unexpected negative relation for independent directors suggests that formal independence without environmental competence or clear mandates can fail to produce, and may even hinder, voluntary disclosure, consistent with studies showing that independence must be matched by relevant skills and role clarity to improve sustainability governance (Mallin et al., 2013). The null moderating role of Tobin's Q implies market valuation does not reliably condition governance effects on CED in this context, possibly due to skewness in Tobin's Q and the dominant influence of direct governance mechanisms (Bebbington et al., 2020; Eccles et al., 2014b).

Managerial and policy implications flow directly from these results. Firms should strengthen supervisory roles substantively by appointing independent commissioners with environmental and technical competence, giving them explicit environmental oversight mandates, ensuring access to independent data/assurance, and tying supervisory evaluation to transparency KPIs. Board expansion should be purposeful: increase board capacity with relevant experts (e.g., environmental engineers, sustainability officers, community liaison specialists) and create committee structures that translate board deliberation into operational reporting processes. Conversely, simply increasing the numerical share of independent directors is insufficient; selection criteria, training, incentives, and delegated responsibilities must ensure directors actively support CED. Regulators and exchanges can support this by requiring disclosure about supervisory environmental remits, encouraging environmental committee formation, and promoting assurance or standardized reporting frameworks (e.g., GHG Protocol, TCFD) tailored to mining. Because firm size alone did not guarantee better disclosure, large firms must still invest in measurement systems and governance translation to realize transparency gains.

This study has several limitations that suggest avenues for future research. First, the focus on Indonesian mining firms limits generalizability; comparative studies across countries or resource sectors would test external validity. Second, the cross-sectional design cannot capture dynamic evolution of governance and disclosure practices, longitudinal or panel studies would clarify causal dynamics. Third, moderator coverage was narrow, Tobin's Q was the sole market proxy and showed skewness; future work should test alternative market pressure indicators (analyst coverage, institutional ownership, media attention) and robustness transformations (winsorizing, log transforms). Fourth, important mediators and moderators, director environmental expertise, presence of environmental or sustainability committees, regulatory enforcement intensity, and assurance practices, were not modeled and could illuminate mechanisms behind the negative %INDDIR effect. Finally, measurement relying on disclosure content

may be sensitive to reporting quality; triangulating with third-party assurance or environmental performance metrics would strengthen inference.

In sum, the evidence indicates governance design matters for carbon transparency in mining: supervisory independence and meaningful board capacity increase CED, while formal director independence without environmental competence can undermine it. Strengthening the substance of governance, skills, mandates, processes, and accountability, offers the most reliable route for mining firms to improve carbon emissions disclosure and thereby manage regulatory, reputational, and stakeholder risks.

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