International Journal of Accounting and Finance in Asia Pacific (IJAFAP)
Vol. 9 No. 2, pp.470-490, June, 2026
E-ISSN: 2684-9763 P-ISSN: 2655-6502
https://www.ejournal.aibpmjournals.com/index.php/IJAFAP

Environmental Performance, Governance Mechanisms, and Carbon Emission Disclosure: Moderating Role of Leverage

Fanji Farman[1*], Erpi Rahman[2], Ina Nusuki[1], Dini Wahjoe Hapsari[1], Dudi Pratomo[1]
[1]Telkom University, Jl. Telekomunikasi, Bandung, West Java 40257, Indonesia
[2]Universitas Sebelas April, Jl. Angkrek Situ No. 19, Sumedang, West Java 45323, Indonesia
*Corresponding Email: fanjifarman@telkomuniversity.ac.id

ARTICLE INFORMATION

Publication information

Research article

HOW TO CITE
Farman, F., Rahman, E., Nusuki, I., Hapsari, D. W., & Pratomo, D. (2026). Environmental performance, governance mechanisms, and carbon emission disclosure: Moderating role of leverage. *International Journal of Accounting and Finance in Asia Pacific*, *9*(2), 470-490.

DOI:
https://doi.org/10.32535/ijafap.v9i2.4415

Received: 12 April 2026
Accepted: 11 May 2026
Published: 20 June 2026

ABSTRACT

Rising demand for environmental transparency has encouraged companies to improve carbon emission disclosure (CED) in sustainability reporting. However, in Indonesia, evidence on the role of corporate governance and sector-specific factors remains limited and inconsistent. This study examines the effects of environmental performance, institutional ownership, and independent commissioners on CED, with leverage as a moderating variable, among Basic Materials, Industrial, and Consumer Cyclicals firms listed on the Indonesia Stock Exchange (IDX) during 2021–2024. Using panel data regression with the Random Effect Model (REM) on 35 companies and 140 observations, the results show that environmental performance positively and significantly affects CED (β = 0.028, p = 0.039). Institutional ownership and independent commissioners do not show significant effects (p = 0.431 and p = 0.474, respectively). Leverage and all interaction terms are also non-significant, indicating that capital structure does not moderate the examined relationships in this context. These findings suggest that substantive environmental performance remains the primary driver of carbon disclosure transparency among high-emission sector firms in Indonesia.

Keywords: Carbon Emission Disclosure; Environmental Performance; Institutional Ownership; Leverage; Sustainability Reporting

JEL Classification: G32; G34; M14; M41; Q56

INTRODUCTION

Climate change is becoming a major global agenda and is forcing companies to increase the transparency of environmental reporting, particularly carbon emission disclosure (CED) as part of their risk management and corporate accountability strategies (Almaqtari et al., 2023). Research shows that the level of corporate climate disclosure has a strong impact on investor perceptions, the cost of capital structure, and firm value, important indicators in long-term investment decisions (Dewi, 2025). In many jurisdictions, including Indonesia, CED disclosure practices are no longer purely voluntary but are increasingly influenced by sustainability reporting regulations and increasing stakeholder demands.

Sustainability reporting in Indonesia has gained significant momentum since the Financial Services Authority (OJK) and the Indonesia Stock Exchange (IDX) introduced mandatory sustainability reporting requirements in 2021. As of early 2025, approximately 97% of IDX-listed companies had submitted sustainability reports; however, the IDX itself acknowledged that substantial gaps remain in emissions data accuracy and disclosure quality (Katadata Media Network, 2025). This pattern reflects a broader global trend, where companies operating under frameworks such as the ISSB and CSRD similarly struggle to translate reporting obligations into substantive environmental transparency (ESG News, 2025). Despite rising reporting volumes, the determinants of CED quality, particularly in high-emission sectors, remain insufficiently understood in the Indonesian context.

In this context, sectoral phenomena are particularly relevant. Companies in the Basic Materials sector, such as mining and the chemical industry, typically have high emissions intensity due to heavy extraction and manufacturing processes, thus facing significant pressure from the public and regulators to improve the quality of emissions disclosure (Chen & Hu, 2026). Companies in the Industrial sector also demonstrate a need for greater transparency regarding emissions, as their operational footprint is closely linked to energy and resource use (Shi & Wang, 2024). Meanwhile, the Consumer Cyclicals sector faces different market pressures, with consumers and shareholders increasingly demanding accurate and credible information regarding the environmental impact of supply chains and products sold.

From a theoretical perspective, environmental performance is linked to CED through Legitimacy Theory, which posits that companies with stronger environmental records tend to disclose more openly to signal legitimacy and maintain social reputation (Chen & Hu, 2026). Empirically, however, findings remain inconsistent; some studies confirm a positive environmental performance CED relationship, while others report null or negative associations depending on industry and institutional context (Doan & Sassen, 2020). Critically, evidence examining this relationship specifically within carbon-intensive sectors in the Indonesian market remains scarce, leaving open the question of whether legitimacy-driven disclosure incentives operate consistently in this emerging market setting.

Institutional ownership represents an external governance mechanism through which investors can exert monitoring pressure on management, potentially encouraging greater environmental transparency. Grounded in Agency Theory, institutional investors with sufficient analytical capacity are expected to demand more credible and comprehensive emissions disclosures to reduce information asymmetry (Dyck et al., 2019). However, empirical evidence on the institutional ownership CED relationship is mixed, while some studies confirm that higher institutional ownership drives disclosure

levels, others find no significant association, with outcomes varying by ownership concentration and jurisdictional characteristics (Al Hawaj & Buallay, 2022). Evidence specific to the Indonesian capital market, where ownership structures and investor behavior differ substantially from developed markets, remains limited and inconclusive.

Independent commissioners serve as an internal governance mechanism designed to strengthen board oversight and improve the quality of corporate reporting. Agency Theory supports this role by arguing that independent board members reduce opportunistic managerial behavior and narrow the information gap between management and shareholders, thereby encouraging more transparent environmental disclosure (Dobija et al., 2023; Shi & Wang, 2024). Despite this theoretical grounding, empirical results from heterogeneous studies across ASEAN markets suggest that the effect of board independence on CED is contingent on broader governance configurations and institutional environments (Mansour et al., 2025). In the Indonesian context, where board independence requirements are relatively recent and enforcement varies, the extent to which independent commissioners effectively drive carbon disclosure quality has not been sufficiently examined.

Furthermore, leverage, or a company's capital structure, is also known to play an important role as a moderating factor in the relationship between governance mechanisms/environmental performance and CED (Wahyuni et al., 2024). High leverage can create pressure from creditors for transparency to assess financial and operational risks, but at the same time, a heavy debt burden can reduce the resources available to prepare comprehensive environmental disclosures (Desai, 2022). Previous international empirical studies have found that firm size and leverage are significant determinants of CED in emerging markets, but evidence specific to the Indonesian market and carbon-intensive sectors is still limited (Dobija et al., 2023). In practice, moderating variables such as leverage are important because they can clarify whether financial pressure weakens or strengthens the relationship between environmental performance/governance and climate information disclosure, especially in dynamic capital market conditions such as Indonesia in the 2021–2024 period.

Despite growing scholarly attention to CED, existing studies have predominantly examined governance mechanisms and environmental performance as independent determinants, without integrating leverage as a conditional moderating factor within a single analytical framework (Al Hawaj & Buallay, 2022; Dobija et al., 2023). Moreover, most prior studies are conducted in developed market contexts, leaving a significant empirical gap in understanding how these relationships operate in emerging markets, particularly Indonesia, where mandatory sustainability reporting has only been enforced since 2021 and where ownership structures, board compositions, and creditor dynamics differ substantially from those in advanced economies. This study addresses these gaps by simultaneously examining the effects of environmental performance, institutional ownership, and independent commissioners on CED, with leverage as a moderating variable, grounded in Legitimacy Theory and Agency Theory. Using panel data from 35 companies across three high-emission sectors during 2021–2024, this study contributes theoretically by extending the applicability of these frameworks to a post-mandatory reporting context in an emerging market, and practically by providing evidence-based insights for regulators, investors, and corporate governance practitioners seeking to improve the quality and consistency of carbon disclosure in Indonesia.

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LITERATURE REVIEW

Theoretical Framework

Legitimacy Theory posits that organizations operate within an implicit social contract, wherein they are expected to align their activities with the values and expectations of the broader society in which they operate. Within this framework, corporate disclosure, including CED, extends beyond compliance requirements, serving as a deliberate corporate strategy to preserve institutional legitimacy and sustain stakeholder acceptance. When a company's environmental performance is perceived positively by stakeholders, voluntary disclosure serves as a signaling mechanism to reinforce legitimacy and build reputational capital (Wahyuningrum et al., 2024). Conversely, companies with weaker environmental records may either withhold information to avoid scrutiny or engage in symbolic disclosure to manage legitimacy threats. In the context of mandatory sustainability reporting in Indonesia post-2021, Legitimacy Theory is particularly relevant as companies in high-emission sectors face heightened public and regulatory expectations to demonstrate accountability through credible carbon disclosure (Karim et al., 2021).

Agency Theory, originally advanced by Jensen and Meckling (2019), describes the conflict of interest arising when a principal delegates decision-making authority to an agent. Information asymmetry, the condition in which managers possess more information than shareholders, creates opportunities for opportunistic managerial behavior, including withholding or manipulating environmental disclosures. Governance mechanisms such as institutional ownership and independent commissioners serve as monitoring instruments that reduce this asymmetry by incentivizing management to disclose more transparent and accurate environmental information (Bedi & Singh, 2024). Institutional investors, by virtue of their analytical capacity and resource base, are better positioned than individual shareholders to scrutinize management behavior and demand comprehensive sustainability disclosures (Kiswanto et al., 2023). Similarly, independent commissioners strengthen board oversight by reducing conflicts of interest and improving the quality of non-financial reporting (Dobija et al., 2023).

Beyond the direct theoretical relationships outlined above, a company's capital structure, specifically its leverage level, is proposed to condition the strength of these relationships. Drawing on both Agency Theory and financial signaling perspectives, highly leveraged companies face dual pressures: creditors demand greater transparency to monitor financial and operational risks, which can amplify disclosure incentives; however, high debt burdens also constrain resources available for voluntary disclosure activities (Desai, 2022; Naseem et al., 2020). This conditional logic suggests that leverage does not influence disclosure directly but rather modifies the effectiveness of environmental performance and governance mechanisms in promoting carbon disclosure. In high-leverage conditions, the pressure for transparency may strengthen the environmental performance–CED and institutional ownership–CED relationships, while simultaneously limiting the discretionary capacity of independent commissioners to advocate for expanded disclosure (Simon et al., 2025). This study, therefore, positions leverage as a moderating variable that captures the financial context in which environmental performance and governance mechanisms operate.

Hypotheses Development

The Effect of Environmental Performance on Carbon Emission Disclosure

Legitimacy Theory argues that companies operate under an implicit social contract, wherein stakeholders, including regulators, investors, and the public, expect organizations to behave in ways consistent with prevailing social norms and

environmental expectations. Within this framework, environmental performance serves as a visible signal of a company's commitment to responsible operations. Firms demonstrating superior environmental records are driven by legitimacy considerations to voluntarily expand their CED, thereby consolidating their reputational standing and reinforcing confidence among key stakeholders (Wahyuningrum et al., 2024). Conversely, companies with poor environmental performance may limit disclosure to avoid reputational damage or regulatory scrutiny. Empirically, studies in emerging market contexts have found consistent support for this relationship: firms with higher environmental performance ratings tend to produce more comprehensive and credible carbon disclosures (Desai, 2022; Karim et al., 2021). However, evidence specific to carbon-intensive sectors in Indonesia remains mixed, underscoring the need for contextual examination in the post-mandatory reporting period. Based on this theoretical and empirical reasoning, this study proposes:

H1: Environmental performance is expected to have a positive effect on CED.

The Effect of Institutional Ownership on Carbon Emission Disclosure

Agency Theory predicts that information asymmetry between management and shareholders creates incentives for opportunistic managerial behavior, including selective or incomplete environmental disclosure (Jensen & Meckling, 2019). Institutional investors such as pension funds, insurance companies, and investment managers possess the analytical resources and incentives to monitor management more effectively than dispersed individual shareholders, thereby reducing this asymmetry and pressuring management toward greater transparency (Dyck et al., 2019). In the context of CED, institutional ownership is theorized to increase disclosure levels by intensifying external monitoring and aligning managerial incentives with broader stakeholder expectations. Empirical evidence from Indonesia and comparable emerging markets provides partial support for this relationship. Kiswanto et al. (2023) found that institutional ownership encourages CED among mining and basic industry companies listed on the IDX, though the effect varies depending on ownership concentration and investor engagement levels. Similarly, Bedi and Singh (2024) confirmed a positive but context-dependent relationship between ownership structure and carbon disclosure in emerging market settings. Given these mixed but theoretically grounded findings, this study proposes:

H2: Institutional ownership is expected to have a positive effect on CED.

The Effect of Independent Commissioners on Carbon Emission Disclosure

Under Agency Theory, independent commissioners function as an internal governance mechanism designed to align managerial behavior with shareholder and stakeholder interests by providing objective oversight of corporate decision-making (Jensen & Meckling, 2019). In the context of sustainability reporting, independent commissioners are theorized to strengthen the quality and scope of CED by reducing managerial discretion over non-financial reporting and promoting accountability to external stakeholders (Dobija et al., 2023). Their independence from management reduces conflicts of interest that might otherwise suppress environmental transparency. Empirically, Karim et al. (2021) found that board governance characteristics, including board independence, positively influence CED among Indonesian listed companies. Studies across ASEAN markets similarly indicate that a higher proportion of independent board members is associated with more comprehensive environmental reporting, though the magnitude of this effect depends on broader governance configurations and the regulatory environment (Bedi & Singh, 2024). In the Indonesian context, where independent commissioner requirements have been formalized under OJK regulations,

this mechanism is expected to play an increasingly significant role in promoting disclosure quality. Based on this reasoning, this study proposes:

H3: Independent commissioners are expected to have a positive effect on CED.

The Moderating Role of Leverage on the Relationship between Environmental Performance and Carbon Emission Disclosure

While environmental performance is theorized to directly motivate carbon disclosure through legitimacy mechanisms, the strength of this relationship may be conditioned by a company's financial leverage. In high-leverage conditions, creditor monitoring intensifies, and lenders require more transparent operational and environmental reporting to assess risk exposure and protect their financial interests (Desai, 2022). This creditor pressure can amplify the disclosure incentives already present in companies with strong environmental performance, strengthening the environmental performance–CED relationship. Conversely, for companies with weaker environmental records, high leverage may suppress disclosure as financial constraints limit the resources available for voluntary reporting activities. In low-leverage conditions, this external creditor pressure is less pronounced, and the environmental performance–CED relationship may depend more heavily on internal governance motivations. The dual role of leverage as both a pressure amplifier and a resource constraint has been documented in emerging market contexts (Naseem et al., 2020; Simon et al., 2025). Based on this interaction logic, this study proposes:

H4: Leverage is expected to moderate the effect of environmental performance on CED.

The Moderating Role of Leverage on the Relationship between Institutional Ownership and Carbon Emission Disclosure

The effectiveness of institutional ownership in promoting CED may also be contingent on a company's leverage level. When leverage is high, institutional investors face compounded information needs; they must simultaneously assess financial solvency and environmental risk exposure, creating stronger incentives to demand comprehensive disclosure (Dyck et al., 2019). In this context, leverage amplifies the monitoring pressure exerted by institutional investors, strengthening the institutional ownership–CED relationship. However, when leverage is excessively high, management's attention and resources may be redirected toward debt servicing and financial restructuring, potentially limiting the extent to which institutional investor pressure translates into actual disclosure improvements (Desai, 2022). In low-leverage companies, institutional investors face less urgency in demanding environmental transparency, as financial risk is less acute. This suggests a conditional moderating effect where the direction and magnitude of leverage's influence on the institutional ownership–CED relationship depends on the degree of financial pressure present. Based on this reasoning, this study proposes:

H5: Leverage is expected to moderate the effect of institutional ownership on CED.

The Moderating Role of Leverage on the Relationship between Independent Commissioners and Carbon Emission Disclosure

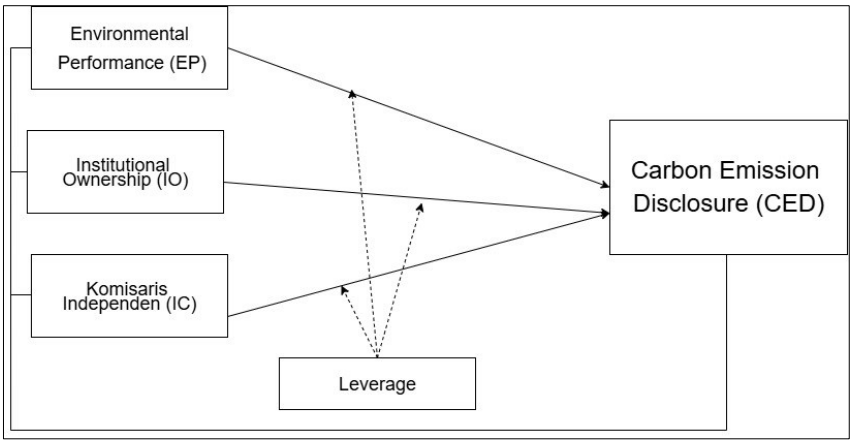
The moderating role of leverage on the independent commissioners–CED relationship operates through a different mechanism compared to its effect on environmental performance and institutional ownership. Independent commissioners, as internal governance actors, derive their influence over disclosure from their oversight authority and independence from management. However, in highly leveraged companies, board attention is frequently diverted toward financial risk management and creditor relations, reducing the bandwidth available for commissioners to advocate for expanded voluntary

environmental disclosure (Naseem et al., 2020). This resource and attention displacement effect suggests that high leverage may weaken the independent commissioners–CED relationship by constraining the effective exercise of board oversight in sustainability matters. Conversely, in companies with moderate leverage, independent commissioners can more freely exercise their oversight role without the competing demands of financial distress management, potentially strengthening their positive influence on disclosure quality (Simon et al., 2025). Given the marginal and context-dependent nature of this moderation, as evidenced by mixed findings in prior studies, this study proposes:

H6: Leverage is expected to moderate the influence of independent commissioners on CED.

Conceptual Framework

Figure 1. Research Framework



The conceptual framework of this study, in Figure 1, illustrates that environmental performance, institutional ownership, and independent commissioners are independent variables hypothesized to directly influence CED as the dependent variable. The environmental performance–CED relationship is grounded in Legitimacy Theory, which posits that companies with stronger environmental performance disclose carbon emission information more extensively to signal legitimacy and maintain stakeholder trust (Karim et al., 2021; Wahyuningrum et al., 2024). The institutional ownership–CED and independent commissioners–CED relationships are explained through Agency Theory, which emphasizes that governance mechanisms reduce information asymmetry and encourage greater environmental transparency (Dobija et al., 2023; Jensen & Meckling, 2019; Kiswanto et al., 2023). Leverage acts as a moderating variable that conditions the strength of these relationships by reflecting the company's level of financial risk and creditor pressure. Companies with high leverage face intensified demands for transparency from creditors, which may amplify or constrain the effectiveness of environmental performance and governance mechanisms in driving carbon disclosure, depending on the degree of financial pressure present (Desai, 2022; Simon et al., 2025).

In addition to this direct influence, leverage acts as a moderating variable that can strengthen or weaken the relationship between environmental performance, institutional ownership, and independent commissioners on CED. Conceptually, leverage reflects a company's level of financial risk. Companies with high levels of debt face pressure from creditors to increase transparency to reduce information risk (Desai, 2022). However, a large debt burden can also limit a company's resources for voluntary disclosure (Naseem

et al., 2020). Therefore, leverage is positioned as a conditional factor determining the strength of the relationship between environmental performance mechanisms and corporate governance at the level of CED.

RESEARCH METHOD

Research Design

This study employs a quantitative approach with an explanatory research design to examine causal relationships among the study variables. The quantitative approach is appropriate because the study aims to test hypotheses and analyze relationships between constructs empirically through numerical data (Creswell, 2014). An explanatory design was selected because it enables researchers to systematically investigate the influence of independent variables on a dependent variable through statistical testing (Sekaran & Bougie, 2016). The unit of analysis is the firm-year observation, forming a balanced panel dataset that offers analytical advantages over purely cross-sectional or time series approaches by simultaneously capturing cross-sectional heterogeneity and temporal variation (Gujarati & Porter, 2009).

Population and Sampling

The study population comprises companies in the Basic Materials, Industrial, and Consumer Cyclicals sectors listed on the IDX during the 2021–2024 period. These three sectors were selected based on their relatively high carbon emission intensity compared to other sectors on the IDX. The Basic Materials sector — encompassing extractive and chemical processing industries — ranks among the most significant sources of industrial greenhouse gas emissions in Indonesia, driven by the resource-intensive nature of their core operational activities (Karim et al., 2021). The Industrial sector similarly generates significant emissions through production operations closely linked to energy and resource consumption (Chen & Hu, 2026). The Consumer Cyclicals sector, while lower in direct emissions, faces increasing supply chain transparency demands from consumers and institutional investors. The selection of these sectors is also consistent with the post-2021 mandatory sustainability reporting framework enforced by the OJK, which places particular emphasis on high-emission industries.

Sample selection employed a purposive sampling technique based on predefined eligibility criteria: first, the company maintained continuous listing within the designated sectors across the entire 2021–2024 observation window; second, the company published sustainability reports or annual reports containing environmental performance and carbon disclosure information; and third, complete data were available for all study variables. Based on these criteria, 35 companies were selected, yielding 140 balanced panel observations.

Measurement

The operationalization of each variable in this study is defined as follows. CED as the dependent variable is measured using a disclosure index based on a checklist of carbon emission-related items derived from sustainability reporting frameworks, including the Global Reporting Initiative (GRI) Standards and OJK sustainability reporting guidelines. Each item is scored 1 if disclosed and 0 if not disclosed, with the total CED score calculated as the ratio of items disclosed to total items in the checklist. This binary checklist approach is consistent with prior studies on carbon disclosure in Indonesian listed companies (Karim et al., 2021; Kiswanto et al., 2023). Environmental performance is measured using the PROPER rating issued annually by the Ministry of Environment and Forestry of Indonesia (KLHK). The PROPER rating is converted to a numerical scale from 1 (black worst) to 5 (gold best), reflecting a company's level of environmental

compliance and performance. This measure has been widely adopted in Indonesian environmental disclosure research due to its objectivity and regulatory credibility (Wahyuningrum et al., 2024). Institutional ownership is measured as the proportion of shares held by institutional investors, including corporations, financial institutions, and government entities, relative to total outstanding shares. Independent commissioners are measured as the proportion of independent commissioners on the board of commissioners relative to total board members, consistent with OJK regulations requiring a minimum of 30% independent representation. Leverage as the moderating variable is measured using the debt to assets ratio (DAR), calculated as total liabilities divided by total assets, reflecting the company's overall financial risk and debt burden (Desai, 2022; Simon et al., 2025).

Data Collection

This study uses secondary data collected from annual reports and sustainability reports of the selected companies, obtained from the IDX official website (idx.co.id) and each company's corporate website. PROPER ratings were sourced from the official website of the Ministry of Environment and Forestry of Indonesia (menlhk.go.id). The observation period covers four fiscal years from 2021 to 2024, coinciding with the post-mandatory sustainability reporting period introduced by the OJK. Data collection followed a systematic documentation method, with each item in the CED checklist independently verified against the contents of the sustainability reports.

Data Analysis

Data analysis was conducted in several sequential stages. First, descriptive statistics were computed to summarize the central tendency and dispersion of each variable. Second, classical assumption tests were performed, including normality, multicollinearity, and heteroscedasticity tests to ensure the regression estimates are unbiased and efficient (Baltagi, 2013; Field, 2018). Third, panel data regression analysis was conducted using three estimation approaches: the Common Effect Model (CEM), the Fixed Effect Model (FEM), and the Random Effect Model (REM) (Basuki & Prawoto, 2016). Model selection followed a sequential testing procedure: model selection commenced with the Chow Test to evaluate the relative appropriateness of CEM versus FEM. FEM was retained when the Chi-square probability fell below the 0.05 threshold. The Hausman Test subsequently assessed whether FEM or REM yielded more consistent estimates, with REM adopted upon observing a probability value exceeding 0.05.

The Hausman Test was then applied to compare FEM and REM, with REM selected when the p-value exceeds 0.05, indicating no systematic difference between fixed and random effects estimators. Based on the Chow Test result (Chi-square $p = 0.0135 < 0.05$) and the Hausman Test result ($p = 0.0888 > 0.05$), the REM was selected as the final model for hypothesis testing in this study. Hypothesis testing was subsequently conducted using: (1) the coefficient of determination (R^2) to assess model explanatory power, (2) the F test to examine the simultaneous significance of all independent variables, and (3) the t test to evaluate the partial significance of each variable individually. All tests were conducted at a significance level of $\alpha = 0.05$ (Gujarati & Porter, 2009).

RESULTS

This section presents the results of empirical analysis based on panel data from 35 companies in the Basic Materials, Industrial, and Consumer Cyclicals sectors listed on the IDX during the 2021–2024 period, comprising 140 balanced panel observations. The

analysis proceeds sequentially through classical assumption tests, panel data model selection, and hypothesis testing using the final selected model.

Descriptive Statistics

Table 1. Descriptive Statistics

	X1	X2	X3	Y	M
Mean	3.143	0.622	0.384	0.872	0.893
Median	3.000	0.671	0.333	0.889	0.539
Maximum	5.000	0.995	0.750	1.000	8.192
Minimum	2.000	0.008	0.111	0.611	-7.732
Std. Dev.	0.663	0.272	0.119	0.091	1.737
Skewness	0.579	-0.797	0.905	-0.400	0.501
Kurtosis	3.861	2.747	3.895	2.881	10.684
Jarque-Bera	12.137	15.185	23.764	3.816	350.239
Probability	0.002	0.001	0.000	0.148	0.000
Sum	440.000	87.061	53.821	122.105	125.073
Sum Sq. Dev.	61.143	10.248	1.962	1.159	419.266
Observations	140	140	140	140	140

Table 1 presents the descriptive statistics for all variables used in this study. The dependent variable, Carbon Emission Disclosure (CED), has a mean value of 0.872, indicating that, on average, sample companies disclose approximately 87% of the carbon emission items in the checklist. Environmental performance has a mean of 3.143, reflecting an average PROPER rating between "blue" and "green" categories, suggesting moderate environmental compliance among the sample firms. Institutional ownership averages 0.622, indicating that institutional investors hold approximately 62% of total shares on average. Independent commissioners average 0.384, which exceeds the minimum 30% threshold required by OJK regulations. Leverage (M) shows a mean of 0.893 with a high standard deviation of 1.737, reflecting considerable variation in debt levels across the sample companies.

Classical Assumption Tests

Normality Test

Figure 2. Normality Test

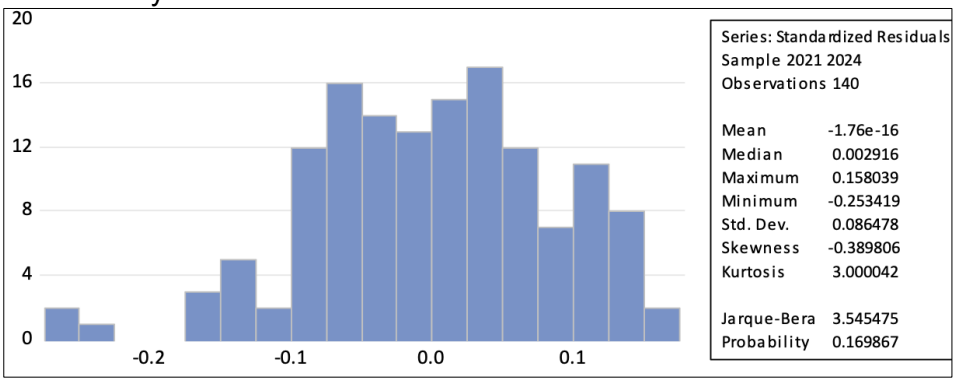


Figure 2 presents the results of the normality test. The Jarque-Bera statistic of 3.545 with a probability of 0.170 (> 0.05) indicates that the residuals are normally distributed, satisfying the normality assumption for panel data regression.

Multicollinearity Test

Table 2. Multicollinearity Test

Variance Inflation Factors			
Date: 02/25/26 Time: 15:21			
Sample: 1 140			
Included observations: 140			
Variable	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.003388	60.27711	NA
X1	0.000172	31.55837	1.336267
X2	0.001325	10.84433	1.725949
X3	0.006093	17.54100	1.519478
M	0.001253	18.56787	3.377248
X1_M	0.091115	11.24504	4.390541
X2_M	0.000849	14.20844	1.719944
X3_M	0.002909	10.56374	1.248105

Table 2 presents the multicollinearity test results. All Centered VIF values are below the threshold of 10. The main variables X1, X2, and X3 record Centered VIF values of 1.336, 1.726, and 1.519, respectively, while the moderating variable (M) records 3.377, and the interaction terms X1_M, X2_M, and X3_M record 4.391, 1.720, and 1.248, respectively. The findings confirm that no multicollinearity problem exists in the model.

Heteroscedasticity Test

Table 3. Heteroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey				
Null hypothesis: Homoskedasticity				
F-statistic	1.087229	Prob. F(7,132)		0.3751
Obs*R-squared	7.631827	Prob. Chi-Square(7)		0.3662
Scaled explained SS	6.763715	Prob. Chi-Square(7)		0.4539
Test Equation:				
Dependent Variable: RESID^2				
Method: Least Squares				
Date: 02/25/26 Time: 15:22				
Sample: 1 140				
Included observations: 140				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.008519	0.006884	1.237456	0.2181
X1	-0.001562	0.001551	-1.007269	0.3156
X2	-0.002627	0.004306	-0.610129	0.5428
X3	0.014706	0.009232	1.592969	0.1136
M	0.001657	0.004187	0.395851	0.6929
X1_M	0.000122	0.001116	0.109648	0.9129
X2_M	-0.003529	0.003445	-1.024222	0.3076
X3_M	3.36E-06	0.006379	0.000527	0.9996
R-squared	0.054513	Mean dependent var		0.007420
Adjusted R-squared	0.004374	S.D. dependent var		0.010515
S.E. of regression	0.010492	Akaike info criterion		-6.221044
Sum squared resid	0.014530	Schwarz criterion		-6.052950
Log likelihood	443.4731	Hannan-Quinn criter.		-6.152736
F-statistic	1.087229	Durbin-Watson stat		1.529620
Prob(F-statistic)	0.375088			

Table 3 presents the heteroscedasticity test results using the Breusch-Pagan-Godfrey method. The F-statistic probability of 0.3751 and the Chi-Square probability of 0.3662 are both greater than 0.05, indicating that the null hypothesis of homoscedasticity cannot be rejected. The findings confirm that the regression model is free from heteroscedasticity and meets the assumption of constant residual variance.

Panel Data Model Selection

Model selection followed a sequential procedure consisting of two stages. The first stage applied the Chow Test to determine whether the CEM or the FEM was more appropriate.

Table 4. Chow Test

Redundant Fixed Effects Tests				
Equation: EQ01				
Test cross-section fixed effects				
Effects Test		Statistic	d.f.	Prob.
Cross-section F		1.379821	(34,98)	0.1126
Cross-section Chi-square		54.764134	34	0.0135
Cross-section fixed effects test equation:				
Dependent Variable: Y				
Method: Panel Least Squares				
Date: 02/25/26 Time: 14:49				
Sample: 2021 2024				
Periods included: 4				
Cross-sections included: 35				
Total panel (balanced) observations: 140				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.754422	0.058208	12.96077	0.0000
X1	0.027657	0.013114	2.108913	0.0368
X2	0.026210	0.036406	0.719929	0.4728
X3	0.044419	0.078061	0.569036	0.5703
M	-0.062063	0.035402	-1.753116	0.0819
X1_M	0.012730	0.009437	1.348913	0.1797
X2_M	0.002386	0.029133	0.081904	0.9348
X3_M	0.046693	0.053936	0.865707	0.3882
R-squared	0.103604	Mean dependent var		0.872180
Adjusted R-squared	0.056067	S.D. dependent var		0.091306
S.E. of regression	0.088710	Akaike info criterion		-1.951450
Sum squared resid	1.038762	Schwarz criterion		-1.783356
Log likelihood	144.6015	Hannan-Quinn criter.		-1.883141
F-statistic	2.179470	Durbin-Watson stat		1.305099
Prob(F-statistic)	0.039950			

Table 4 presents the Chow Test results. The Cross-section Chi-square statistic yields a probability of 0.0135 (< 0.05), leading to rejection of the null hypothesis that individual effects are redundant. The findings, therefore, indicate that the FEM is more appropriate than the CEM at this stage.

The second stage applied the Hausman Test to determine whether the FEM or the REM was more appropriate.

International Journal of Accounting and Finance in Asia Pacific (IJAFAP)
Vol. 9 No. 2, pp.470-490, June, 2026
E-ISSN: 2684-9763 P-ISSN: 2655-6502
https://www.ejournal.aibpmjournals.com/index.php/IJAFAP

Table 5. Hausman Test

Correlated Random Effects - Hausman Test				
Equation: EQ01				
Test cross-section random effects				
Test Summary		Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random		12.377412	7	0.0888
Cross-section random effects test comparisons:				
Variable	Fixed	Random	Var(Diff.)	Prob.
X1	0.028737	0.027944	0.000453	0.9703
X2	0.004555	0.029708	0.010775	0.8085
X3	0.154095	0.056288	0.007416	0.2560
M	-0.032765	-0.061353	0.001161	0.4014
X1_M	0.024230	0.014194	0.000082	0.2676
X2_M	-0.070334	-0.002621	0.002433	0.1699
X3_M	0.002590	0.042678	0.002737	0.4435

Table 5 presents the Hausman Test results. The Chi-square statistic yields a probability of 0.0888 (> 0.05), indicating a failure to reject the null hypothesis that the random effects estimator is consistent and efficient. Under the Hausman Test framework, failure to reject the null hypothesis supports the selection of the REM over the FEM, as there is no systematic difference between the two estimators. The data confirm that the REM is the final selected model for hypothesis testing in this study. The Lagrange Multiplier test was not required, given the conclusive result of the Hausman Test.

Panel Data Regression Analysis - REM

Table 6. REM Results

Dependent Variable: Y				
Method: Panel EGLS (Cross-section random effects)				
Date: 02/25/26 Time: 14:50				
Sample: 2021 2024				
Periods included: 4				
Cross-sections included: 35				
Total panel (balanced) observations: 140				
Swamy and Arora estimator of component variances				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.746321	0.058803	12.69179	0.0000
X1	0.027944	0.013420	2.082329	0.0392
X2	0.029708	0.037591	0.790305	0.4308
X3	0.056288	0.078310	0.718777	0.4735
M	-0.061353	0.035124	-1.746760	0.0830
X1_M	0.014194	0.009372	1.514555	0.1323
X2_M	-0.002621	0.029739	-0.088146	0.9299
X3_M	0.042678	0.053464	0.798246	0.4262
Effects Specification				
			S.D.	Rho
Cross-section random			0.019742	0.0516
Idiosyncratic random			0.084665	0.9484
Weighted Statistics				
R-squared	0.104018	Mean dependent var		0.790449
Adjusted R-squared	0.076504	S.D. dependent var		0.088921
S.E. of regression	0.086372	Sum squared resid		0.984740
F-statistic	2.189206	Durbin-Watson stat		1.363873

Prob(F-statistic)	0.039080		
Unweighted Statistics			
R-squared	0.102959	Mean dependent var	0.872180
Sum squared resid	1.039509	Durbin-Watson stat	1.292013

Table 6 presents the results of panel data regression using the REM, which serves as the basis for all hypothesis testing in this study. The R-squared value of 0.1040 indicates that the model explains approximately 10.4% of the variation in CED, while the remaining 89.6% is explained by factors outside the model. The F-statistic probability of 0.0391 (< 0.05) confirms that all independent variables jointly and significantly influence CED, satisfying the simultaneous significance test.

Hypothesis Testing

Table 6 presents the results of the partial hypothesis testing at a significance level of α = 0.05. The results show that environmental performance (X1) has a regression coefficient of 0.028 and a probability value of 0.039, which is lower than 0.05. This indicates that environmental performance has a positive and statistically significant effect on CED, meaning that companies with better environmental performance tend to disclose carbon emission information more extensively; therefore, H1 is supported. Meanwhile, institutional ownership (X2) has a regression coefficient of 0.030 with a probability value of 0.431, and independent commissioners (X3) have a regression coefficient of 0.056 with a probability value of 0.474. Since both probability values are greater than 0.05, institutional ownership and independent commissioners do not have a statistically significant effect on CED; thus, H2 and H3 are not supported.

Furthermore, the moderating role of leverage is tested through the interaction variables. The interaction between environmental performance and leverage (X1_M) has a coefficient of 0.014 with a probability value of 0.132, the interaction between institutional ownership and leverage (X2_M) has a coefficient of -0.003 with a probability value of 0.930, and the interaction between independent commissioners and leverage (X3_M) has a coefficient of 0.043 with a probability value of 0.426. Because all three probability values exceed 0.05, leverage does not significantly moderate the relationship between environmental performance, institutional ownership, or independent commissioners and CED; therefore, H4, H5, and H6 are not supported. Overall, the findings indicate that environmental performance is the only variable that significantly increases CED, while institutional ownership, independent commissioners, and the moderating effect of leverage are not statistically significant.

DISCUSSION

Environmental Performance and Carbon Emission Disclosure

The results of this study confirm that environmental performance has a positive and significant effect on CED (β = 0.028, p = 0.039), supporting H1. This finding is theoretically grounded in Legitimacy Theory, which argues that firms subject to elevated environmental oversight tend to deploy disclosure practices as a strategic instrument for communicating adherence to societal norms and sustaining their legitimacy in the eyes of relevant stakeholders (Wahyuningrum et al., 2024). In the Indonesian context, where the PROPER rating system provides a credible, government-issued environmental performance benchmark, companies achieving higher ratings are motivated to communicate their environmental standing through more comprehensive carbon disclosures, thereby reinforcing their reputational capital and differentiating themselves from lower-performing peers.

This result is consistent with several prior studies. Wahyuningrum et al. (2024) found that environmental performance positively and significantly influences CED among Indonesian listed companies with PROPER ratings, confirming that the legitimacy signaling mechanism operates effectively within the Indonesian regulatory setting. Similarly, Fuadi et al. (2025) found that PROPER ratings positively affect CED among high-polluting Indonesian companies during 2021–2024, directly paralleling the sector coverage and observation period of the present study. Karim et al. (2021) further corroborate this finding in the context of Indonesian corporate governance, while Desai et al. (2022) demonstrate that companies facing stronger environmental pressure in emerging markets tend to disclose more actively. Collectively, these findings reinforce the view that in carbon-intensive sectors such as Basic Materials and Industrials, substantive environmental performance as objectively measured by the PROPER system remains the most robust and consistent predictor of disclosure quality. From a practical standpoint, this result suggests that improving genuine environmental performance, rather than symbolic compliance with reporting requirements, is the most effective pathway to enhancing carbon disclosure credibility in the Indonesian capital market.

Institutional Ownership and Carbon Emission Disclosure

Contrary to the theoretical expectation derived from Agency Theory, the results show that institutional ownership does not have a significant effect on CED ($\beta = 0.030$, $p = 0.431$), leading to the non-support of H2. Despite institutional investors holding an average of 62.2% of shares in the sample, their monitoring capacity has not translated into measurable improvements in carbon transparency among the sampled companies.

This non-significant finding is consistent with a growing body of evidence from the Indonesian context. Yasa and Sudana (2025) found that institutional ownership does not exhibit a significant effect on CED among energy sector companies listed on the IDX during 2020–2023, a period that closely overlaps with the present study. Furthermore, Wahyuningrum et al. (2024) found that institutional ownership has an insignificant influence on carbon emissions disclosure, attributing this to the passive monitoring orientation of dominant institutional shareholders.

The non-significant result may be attributed to the nature of institutional ownership in Indonesia, where a significant proportion of institutional shares is held by government-linked entities, holding companies, and family-controlled institutions whose investment objectives are not primarily aligned with ESG transparency demands. Bedi and Singh (2024) further emphasize that the monitoring effectiveness of institutional investors is highly context-dependent, varying by investor type and engagement level. These findings collectively suggest that the mere presence of institutional ownership is insufficient to drive carbon disclosure improvements; the quality, orientation, and ESG engagement of institutional investors matter more than their ownership proportion.

Independent Commissioners and Carbon Emission Disclosure

The results show that independent commissioners do not have a significant effect on CED ($\beta = 0.056$, $p = 0.474$), leading to the non-support of H3. This finding suggests that the formal presence of independent commissioners on the board does not, by itself, produce substantive improvements in carbon disclosure quality among the sampled companies.

This result aligns with mixed evidence from prior Indonesian and regional governance research. Yasa and Sudana (2025) similarly found that the proportion of independent commissioners does not exhibit a significant effect on CED, despite the OJK's mandatory

minimum independence requirement. Bedi and Singh (2024) further argue that board independence produces stronger effects on environmental disclosure when combined with sustainability-oriented governance attributes, including dedicated environmental committees and directors with relevant ESG expertise.

In the Indonesian context, the average proportion of independent commissioners in the sample (38.4%) is only marginally above the OJK regulatory minimum of 30%, suggesting that many companies may be fulfilling this requirement structurally rather than substantively. The absence of meaningful board engagement with sustainability issues beyond structural compliance likely explains the non-significant finding. Avinda et al. (2025) also note that governance mechanisms' effectiveness in influencing corporate reporting behavior is moderated by firm-specific characteristics, further supporting the context-dependent nature of this finding.

The Moderating Role of Leverage

The results indicate that leverage does not significantly moderate any of the three examined relationships: Environmental performance CED (β = 0.014, p = 0.132), institutional ownership–CED (β = -0.003, p = 0.930), or independent commissioners–CED (β = 0.043, p = 0.426), leading to the non-support of H4, H5, and H6. These findings suggest that capital structure does not function as a meaningful conditional factor shaping the relationship between environmental performance, governance mechanisms, and CED during the 2021–2024 period.

This result partially departs from the theoretical prediction that highly leveraged companies face intensified creditor pressure for transparency (Desai, 2022; Naseem et al., 2020). However, several contextual factors may explain these non-significant moderating effects. First, the extremely high variability in leverage observed in the sample, with the debt-to-assets ratio ranging from -7.732 to 8.192 and a standard deviation of 1.737, likely diluted any systematic moderating pattern, as extreme outliers in leverage may have masked the conditional effects. Second, Simon et al. (2025) note that the relationship between capital structure and governance effectiveness is highly sensitive to sector-specific financial conditions and the degree of creditor engagement with ESG issues, both of which vary considerably across the three sectors examined.

The non-significant moderating effect of leverage may also reflect the sector-specific nature of the leverage–disclosure relationship, as Paramita and Prasetio (2025) demonstrate that the influence of leverage on sustainability reporting varies considerably depending on industry characteristics and financial risk profiles. The absence of significant moderation may also reflect the relatively early and formative stage of carbon disclosure practice in Indonesia post-2021, where disclosure decisions are primarily driven by environmental performance and regulatory compliance rather than by capital structure considerations. As Indonesia's carbon market matures and creditor ESG engagement deepens, the moderating role of leverage in the environmental performance/governance CED relationship may become more pronounced.

Theoretical and Practical Implications

From a theoretical standpoint, this study extends the CED literature by demonstrating that in the post-mandatory reporting context of an emerging market, Legitimacy Theory provides stronger explanatory power for disclosure behavior than Agency Theory-based governance mechanisms. Environmental performance as captured by the PROPER rating consistently drives disclosure, while institutional ownership and independent commissioners do not produce significant effects in isolation. This finding contributes to the growing body of evidence suggesting that Agency Theory-based governance

mechanisms require complementary conditions, including active investor ESG engagement, board sustainability competence, and creditor pressure to generate measurable disclosure outcomes in emerging market settings (Bedi & Singh, 2024; Kiswanto et al., 2023).

From a practical standpoint, these findings carry several implications. For corporate managers, the results confirm that genuine improvements in environmental performance represent the most credible and effective strategy for enhancing carbon disclosure quality, consistent with the legitimacy signaling perspective (Karim et al., 2021; Wahyuningrum et al., 2024). For regulators and the OJK, the non-significant governance effects highlight the limitations of structural compliance requirements in driving substantive disclosure improvements; policy interventions should focus on enhancing board sustainability competence, improving ESG-oriented institutional investor engagement, and strengthening creditor incentives for environmental transparency. For investors, particularly those with ESG mandates, these results underscore the importance of evaluating environmental performance ratings alongside governance structures when assessing the quality and reliability of corporate carbon disclosures in the Indonesian market (Avinda et al., 2025; Simon et al., 2025).

CONCLUSION

This study examines the effects of environmental performance, institutional ownership, and independent commissioners on CED, with leverage as a moderating variable, among companies in the Basic Materials, Industrial, and Consumer Cyclicals sectors listed on the IDX during 2021–2024. Based on panel data regression analysis using the REM selected through a sequential Chow Test ($p = 0.0135$) and Hausman Test ($p = 0.0888$) procedure, the following conclusions are drawn.

First, environmental performance has a positive and significant effect on CED, confirming H1. Companies with higher PROPER ratings tend to disclose carbon emission information more extensively, consistent with the predictions of Legitimacy Theory. This finding suggests that substantive environmental performance remains the primary and most consistent driver of carbon disclosure quality in the Indonesian capital market during the post-mandatory reporting period.

Second, institutional ownership does not have a significant effect on CED, leading to the non-support of H2. Despite institutional investors holding majority ownership positions in the sampled companies, their monitoring capacity has not translated into measurable improvements in carbon transparency. This finding suggests that the effectiveness of institutional ownership as a governance mechanism for disclosure is context-dependent and may require higher-quality ESG-oriented investor engagement to produce measurable outcomes.

Third, independent commissioners do not have a significant effect on CED, leading to the non-support of H3. The structural presence of independent commissioners at levels marginally above the OJK regulatory minimum does not appear sufficient to drive substantive improvements in carbon disclosure quality, suggesting that board independence requirements need to be complemented by sustainability competence and genuine oversight engagement.

Fourth, leverage does not significantly moderate any of the three examined relationships between environmental performance and CED, institutional ownership and CED, or independent commissioners and CED, leading to the non-support of H4, H5, and H6.

Capital structure does not function as a meaningful conditional factor in shaping disclosure behavior during the study period, possibly reflecting the high variability in leverage across sectors and the early stage of carbon disclosure maturity in Indonesia.

Overall, these findings confirm that environmental performance grounded in Legitimacy Theory provides stronger and more consistent explanatory power for CED than Agency Theory-based governance mechanisms in the Indonesian emerging market context. Governance mechanisms, while theoretically important, may require complementary conditions such as board sustainability expertise, ESG-oriented investor engagement, and stronger creditor pressure to produce statistically significant disclosure effects.

LIMITATION

This study has several limitations that should be considered when interpreting its findings. First, the observation period of four years (2021–2024) limits the ability to capture long-term trends in disclosure behavior, particularly given that mandatory sustainability reporting was only introduced in 2021. Second, the relatively low coefficient of determination ($R^2 = 0.104$) indicates that a substantial proportion of variation in CED is explained by factors outside the model, such as firm size, profitability, international exposure, media pressure, and regulatory enforcement intensity. Third, the study focuses on three specific sectors, which may limit the generalizability of the findings to other industries. Future research is recommended to extend the observation period, incorporate additional governance and firm-level control variables, and apply more dynamic panel estimation methods to capture temporal dynamics in the environmental performance/governance–CED relationship across broader sectoral and institutional contexts in Indonesia.

ACKNOWLEDGMENT

The authors express their appreciation and gratitude to all parties who provided support throughout this research process, including data provision, academic input, and moral support. They also express their gratitude to colleagues and institutions that provided the opportunity and research facilities that enabled this study to be successfully completed.

DECLARATION OF CONFLICTING INTERESTS

The authors declare that there is no potential conflict of interest related to the research, authorship, and/or publication of this article. The entire research process was conducted independently without any influence from any party that could affect the objectivity of the research results.

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ABOUT THE AUTHOR(S)

1st Author
Fanji Farman, SE., M.Ak is a lecturer in the Accounting Study Program, Faculty of Economics and Business, Telkom University Bandung, West Java Province, Indonesia. He has more than nine years of teaching experience. His research interests include Financial Accounting and Financial Management of MSMEs.
Email: fanjifarman@telkomuniversity.ac.id
ORCID ID: https://orcid.org/0009-0009-3439-0813

2nd Author
Erpi Rahman, SE., M.Ak is a lecturer in the Accounting Study Program, Faculty of Economics and Business, Sebelas April University, West Java Province, Indonesia, he has more than ten years of teaching experience. His research interests include the fields of Financial Accounting and Auditing.
Email: erpirahman.feb@unsap.ac.id
ORCID ID: https://orcid.org/0009-0008-5677-6656

3rd Author
Ina Nusuki, SE.Ak, M.Ak., a 28-year practitioner in telecommunications company finance, subsequently taught in the Accounting Department of the Faculty of Economics

and Business, Telkom University. Her research interests include public finance and auditing.
Email: Inanusukiin@telkomuniversity.ac.id
ORCID ID: https://orcid.org/0009-0004-2770-7142

4th Author
Dr. Dini Wahjoe Hapsari, S.E., M.Sc., Ak., CA is a lecturer in the Accounting Study Program, Faculty of Economics and Business, Telkom University Bandung, West Java Province, Indonesia. She has more than twenty-five years of teaching experience. She completed her doctoral studies in January 2022 at Padjadjaran University. Her research interests include Financial Accounting, Company Performance.
Email: dinihapsari@telkomuniversity.ac.id
ORCID ID: https://orcid.org/0000-0002-1496-1000

5th Author
Dudi Pratomo, S.E.T., M.Ak., Ph.D. is a lecturer in the Accounting Study Program, Faculty of Economics and Business, Telkom University Bandung, West Java Province, Indonesia. He has more than 24 years of teaching experience. He completed his doctoral studies in 2021 at Universiti Sains Malaysia. His research interests include Earnings Management, Governance. Accounting Conservatism, Creative Accounting.
Email: dudipratomo@telkomuniversity.ac.id
ORCID ID: https://orcid.org/0000-0002-4649-2181