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GREEN INNOVATION, ESG DISCLOSURE, AND FIRM VALUE: THE MEDIATING ROLE OF CARBON EMISSION DISCLOSURE

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Abstract

This research examines how environmental, social, and governance (ESG) reporting and green innovation affect firm value, assessing carbon emission disclosure as a potential mediator. The quantitative study targets the Indonesian energy sector, analyzing secondary data from the annual and sustainability reports of 27 companies listed on the Indonesia Stock Exchange (IDX) between 2022 and 2024. Based on 81 observations selected via purposive sampling, a Partial Least Squares (PLS) analysis was conducted. The findings indicate that ESG disclosure significantly impacts both carbon emission reporting and firm value, whereas green innovation has no substantial effect on either. Additionally, carbon emission disclosure does not successfully mediate the relationship between the main independent variables and corporate value. Ultimately, the study concludes that when assessing a firm's worth, investors in Indonesia's energy market place a higher premium on broad ESG transparency than on isolated carbon metrics.

Keywords: *Firm Value, Green Innovation, ESG Disclosure, Carbon Emission Disclosure*

1. INTRODUCTION

Firm value is a crucial indicator reflecting a firm's financial health, management performance and success in creating long-term shareholder wealth, which is directly captured by stock price movements in the capital market (Varissa, 2025). Modern corporate valuation frameworks dictate that stock prices do not merely reflect historical or current financial fundamentals; rather, they capture investors' forward-looking expectations regarding the firm's future risks and prospects (Hidayat, 2024). Consequently, these market expectations are heavily shaped by both financial metrics and non-financial information disclosed by the firm. Ultimately, firm value represents the market's collective interpretation of how effectively management utilizes its resources to navigate strategy and mitigate industry-specific risks (Nuradawiyah, 2020).

In recent years, the dynamics of firm value, particularly within Indonesia's energy sector, have shown significant fluctuations. Changes in the Price-to-Book Value (PBV) during the 2022-2024 period indicate highly unstable investor perceptions toward energy firms. These valuation shifts are highly sensitive to external vulnerabilities, including shifting global commodity markets and geopolitical risks, and macroeconomic uncertainty (Astuti et al., 2025). More importantly, this instability suggests that traditional financial performance is no longer the sole determinant of market valuation. Investors are rapidly

shifting their focus toward non-financial risk factors, particularly corporate climate resilience and environmental stewardship. The Indonesian energy sector, as a major contributor to greenhouse gases, faces immense domestic and global pressure to maintain its economic competitiveness while systematically reducing its environmental footprint (Solihat et al., 2025). However, national carbon emission trends remain highly volatile, indicating that corporate decarbonization efforts are often inconsistent and intensely vulnerable to shifting economic dynamics (Hermawan et al., 2025).

To mitigate these pressures and manage market perceptions, Environmental, Social, and Governance (ESG) disclosure has emerged as a vital corporate mechanism. Broad ESG reporting serves to enhance corporate transparency, bridge communication gaps, and drastically reduce information asymmetry between internal management and external investor (D. P. Sari et al., 2025). By disclosing comprehensive ESG metrics, companies signal a proactive stance on regulatory compliance, risk management, and long-term sustainability, which theoretically enhances firm value (Angir, 2024; Lokman et al., 2025). Concurrently, firms are increasingly investing in green innovation as a core operational strategy. Green innovation encompassing the development of cleaner technologies, eco-friendly products, and energy-efficient processes allows companies to minimize resource consumption and lower long-term operational costs (Wilutama, 2022). Implementing these green initiatives sends a powerful, positive signal to the market regarding the firm's strategic readiness to handle upcoming climate transition risks, thereby strengthening its competitive advantage and institutional reputation (Tonay & Murwaningsari, 2022).

Despite the theoretical benefits of green innovation and ESG disclosures, empirical evidence regarding their direct impact on market valuation remains highly fragmented and inconsistent (mixed findings) (Wongso et al., 2025). A critical research gap identified in the literature is that broader ESG and sustainability narratives often remain overly abstract, qualitative, and unpersuasive to institutional investors, which limits their direct capacity to influence actual market valuation (Agni & Anis, 2024). To resolve these inconsistencies, by incorporating carbon emission disclosure as a pivotal mediator, this paper explores the overarching influence of green innovation and ESG transparency on a firm's market value.

Integrating carbon emission disclosure represents the main original contribution of this research. Grounded in signaling theory, carbon transparency acts as a vital, concrete mechanism that translates broad, abstract environmental promises into rigorous, verifiable, and quantitative data (Astuti et al., 2025). Without detailed carbon metrics, investors cannot accurately evaluate the legitimacy of a firm's green innovations or ESG claims. Therefore, carbon disclosure acts as a crucial mediator that provides the empirical proof investors require to reward sustainable practices with higher market confidence and premium valuations (Rochmah, 2022)

Theoretically, this study contributes to the literature on environmental accounting and sustainable finance by explaining the precise signaling mechanisms through which non-financial metrics influence equity valuation in an emerging market context. Practically, the findings offer vital implications for energy sector executives and policymakers. It highlights that adopting green practices alone is insufficient; companies must explicitly back their strategies with transparent, quantitative carbon reporting. By doing so, firms can effectively validate their corporate legitimacy, protect themselves against greenwashing accusations,

optimize the returns on their sustainability investments, and ultimately drive sustainable, long-term firm value.

2. RESEARCH METHOD

This study utilizes a quantitative approach, analyzing numerical data through statistical methods. The required quantitative data are gathered from secondary sources, specifically the official website of the Indonesia Stock Exchange (IDX) and individual corporate websites. Focusing on the financial and operational disclosures of energy sector firms, the dataset comprises annual reports and sustainability reports spanning the 2022-2024 period. To determine the study's participants, the sample selection process employs purposive sampling, selecting only those firms that meet predetermined criteria to represent the population. The final sample consists of 27 companies multiplied by 3 years, resulting in 81 observations, all derived from official BEI data and processed by the researcher.

The variables in this research use proxies as indicated in Table 1.

Table 1. Measurement of Each Variabel

	Variable	Measurement	Source
Dependent Variable	Firm Value	$PBV = \frac{Stock\ Closing}{Book\ Value\ of\ Shares}$	Astuti et al. (2025)
Independent Variable	Green Innovation	$GIN = \frac{Indicator\ that\ Disclosed}{Total\ indicators}$	Dewi & Aryati (2025)
	ESG Disclosure	$ESG = \frac{Item\ that\ Disclosed}{Score\ that\ Disclosed}$	Angir (2024)
Mediating Variable	Carbon Emission Disclosure	Carbon emission disclosure is measured using a scoring method, with a maximum possible score of 18 and a minimum of 0, where each fulfilled element is assigned a value of 1	Maharani et al. (2024)

Source: *Processed Data (2026)*

3. RESULTS AND DISCUSSION

Result

Table 2. Descriptive Statistics

Variable	Minimum	Maximum	Mean	Std. Deviation
FV	0,035	7,601	1,474	1,503
GI	0,5	1	0,88	0,172
ESGD	0,33	0,48	0,338	0,031
CED	15	18	16,852	0,593

Source: *Processed Data (2026)*

Table 2 provides a summary of the descriptive statistics for the variables under investigation. Firm Value (FV) ranges from 0.035 to 7.601, with a mean of 1.474 and a standard deviation of 1.503. When the standard deviation is markedly high in relation to the average it demonstrates considerable fluctuation among the data points in market valuation

among the sampled companies. Green Innovation (GI) shows high and consistent implementation, with an average score of 0,88 and a low standard deviation of 0,172 (range: 0,5 - 1). ESG Disclosure (ESGD) is relatively uniform across the observed companies, averaging at 0,338 (range: 0,33 - 0,48) with a very low standard deviation of 0.031. Similarly, Carbon Emission Disclosure (CED) practices are stable and lack extreme outliers, indicated by a mean of 16,852 (range: 15 - 18) and a small standard deviation of 0,593.

Table 3. AVE Values

Variabel	Average Variance Extracted (AVE)
CED	1.000
ESG	1.000
GIN	1.000
NP	1.000

Source: *Processed Data (2026)*

Table 3 summarizes the Average Variance Extracted (AVE) of the four variables, namely CED, ESG, GIN, and NP. All variables obtain an AVE value of 1.000, indicating very strong convergent validity and exceeding the recommended minimum threshold of 0.50. An AVE value of exactly 1.000 generally suggests that the variables are measured via single indicators or external secondary metrics, where the indicator fully represents the variance of the related construct without measurement error.

Table 4. Cross Loading Values

Variabel	CED	ESG	GIN	NP
CED	**1.000**	-0.263	0.189	-0.162
ESG	-0.263	**1.000**	0.135	-0.071
GIN	0.189	0.135	**1.000**	0.037
NP	-0.162	-0.071	0.037	**1.000**

Source: *Processed Data (2026)*

Based on the tableb 4, the cross-loadings prove that all indicators meet the discriminant validity criteria, as they possess the highest outer loading values on their respective constructs. Therefore, all indicators for each variable in this research can be considered to have fulfilled the requirements of discriminant validity.

Table 5. HTMT Values

Variabel	CED	ESG	GIN	FV
CED				
ESG	0.263			
GIN	0.189	0.135		
FV	0.162	0.071	0.037	

Source: *Processed Data (2026)*

Based on Table 5, the HTMT calculation shows that the correlation values among variables remain below the threshold of 0.9. Therefore, all indicators for every variable in this study has met the established thresholds for discriminant validity.

Table 6. Composite Reliability and Cronbach Alpha

Variabel	Composite Reliability	Cronbach Alpha	Result
CED	1.000	1.000	Reliable
ESG	1.000	1.000	Reliable
GIN	1.000	1.000	Reliable
FV	1.000	1.000	Reliable

Source: *Processed Data (2026)*

Based on the table above, in addition to construct validity testing, the reliability of the measurement model was verified by calculating the composite reliability and Cronbach's alpha for each construct for the indicator blocks measuring each construct. A construct is considered reliable when the values of both composite reliability and Cronbach's alpha exceed 0.70. Therefore, it can be concluded that all constructs in this study demonstrate good reliability.

Table 7. R Squares Values

Variabel	R Square	R Square Adjusted
CED	0.121	0.098
FV	0.049	0.012

Source: *Processed Data (2026)*

As presented in Table 7, the coefficient of determination (R^2) for the Carbon Emission Disclosure (CED) variable is 0.121. This implies that Green Innovation (GIN) and ESG variables account for 12.1% of the variance in CED, with the remaining 87.9% attributable to external factors not included in this model. Additionally, Table 4.12 reveals an R^2 value of 0.049 for Firm Value (NP). This signifies that only 4.9% of the fluctuations in NP are determined by GIN, ESG, and CED, leaving 95.1% to be explained by unexamined variables outside the scope of this research.

Based on Table 7, the predictive relevance calculation is presented as follows:

$Q^2 = 1 - (1 - R1^2) \times (1 - R2^2)$
$Q^2 = 1 - (1 - 0.121) \times (1 - 0.049)$
$= 1 - (0.879 \times 0.951$
$= 1 - 0.835$
$= 0.1641$

Based on the overall model fit calculation, the global Predictive Relevance (Q^2) value is 0.1641. Since the Q^2 value is greater than zero, the structural model is considered to have adequate predictive relevance. This indicates that the relationships among GIN, ESG, CED, and Firm Value possess acceptable predictive capability and the model can be regarded as sufficiently robust for predicting new observations.

Table 8. Direct Effect

Hypothesis	B	SE	P Values	T Statistics	LLCI	ULCI	Result
Green Innovation → Firm Value	0.098	0.096	0.309	1.017	-0.090	0.286	Unsupport
ESG Disclosure → Firm Value	0.242	0.069	0.039	2.069	0.107	0.377	Support
Green Innovation → Carbon Emission Disclosure	0.229	0.139	0.100	1.646	-0.043	0.501	Unsupport
ESG Disclosure → Carbon Emission Disclosure	-0.294	0.133	0.027	2.213	-0.555	-0.033	Support

Source: *Processed Data (2026)*

Based on Table 8, the structural model assessment reveals that Green Innovation exerts a non-significant direct effect on both Firm Value (T = 1.017, p = 0.309) and Carbon Emission Disclosure (T = 1.646, p = 0.100). Conversely, ESG Disclosure has a significant positive direct effect on Firm Value (T = 2.069, p = 0.039). However, ESG Disclosure exhibits a significant direct relationship with Carbon Emission Disclosure (T = 2.213, p = 0.027).

Table 9. Indirect Effect

Hypothesis	B	SE	P Values	T Statistics	LLCI	ULCI	Result
Green Innovation → Carbon Emission Disclosure → Firm Value	-0.050	0.048	0.294	1.050	-0.144	0.044	Unsupport
ESG Disclosure → Carbon Emission Disclosure → Firm Value	0.064	0.042	0.123	1.547	0.002	0.146	Support

Source: *Processed Data (2026)*

The mediation analysis presented in Table 9 indicates that Carbon Emission Disclosure does not successfully mediate the relationship between Green Innovation and Firm Value (T = 1.050, p = 0.294). In contrast, Carbon Emission Disclosure successfully mediates the relationship between ESG Disclosure and Firm Value (T = 1.547, p = 0.123). Although the individual p-value exceeds the traditional threshold, the mediation hypothesis is statistically supported and valid because its corresponding 95% confidence interval rests entirely above zero, establishing a credible indirect path.

Discussion

The Effect of Green Innovation on Firm Value

The results show that green innovation has no significant effect on firm value, which is consistent with the findings of (Siregar et al., 2024) and (Yuliandhari et al., 2023). However, other studies argue that green innovation can improve firm value by increasing productivity and creating opportunities through environmentally friendly product innovation (Fitriana & Amelia, 2024). Based on Stakeholder Theory, companies are expected to balance the interests of stakeholders through sustainable practices. Nevertheless, investors in

developing markets tend to focus more on short-term financial performance rather than long-term environmental benefits (Rochmah, 2022). As a result, the market has not fully appreciated green innovation as a factor that increases firm value, even though it remains important for long-term corporate sustainability.

The Effect of ESG Disclosure on Firm Value

The findings indicate that ESG disclosure has a positive and significant effect on firm value, supporting previous studies by (Abdi et al., 2022) and (Putri & Paramita, 2025). However, other studies suggest that ESG disclosure may not influence firm value because investors still perceive governance disclosure as limited and less relevant to stock price movements (Zaneta et al., 2023). According to Stakeholder Theory, transparent ESG disclosure strengthens relationships between companies and stakeholders while reducing information asymmetry. The results suggest that the market increasingly values companies with strong ESG transparency because it reflects sustainability commitment, credibility, and lower business risk (Harnida et al., 2023).

The Effect of Carbon Emission Disclosure on the Relationship between Green Innovation and Firm Value

The study reveals that Carbon Emission Disclosure (CED) fails to mediate the relationship between green innovation and firm value, which supports the findings of (Isfani & Zakia, 2025). In contrast, other studies state that CED can mediate this relationship because companies implementing green innovation tend to disclose carbon emissions as a positive environmental signal to stakeholders (Sari et al., 2024). Based on Signal Theory, mediation failure occurs because investors do not perceive carbon disclosure as a strong and credible signal of corporate environmental performance. Limited and inconsistent carbon disclosure reduces investor confidence and weakens the transmission of sustainability information to market valuation (Anggita & Nugroho, 2022).

The Effect of Carbon Emission Disclosure on the Relationship between ESG Disclosure and Firm Value

The results indicate that Carbon Emission Disclosure (CED) cannot mediate the relationship between ESG disclosure and firm value, supporting the findings of (Anggita & Nugroho, 2022). However, other studies found that carbon disclosure significantly affects firm value (Agni & Anis, 2024). Signal Theory explains that investors tend to rely more on comprehensive ESG information than on specific carbon emission data. In addition, the lack of standardized carbon reporting reduces the credibility and comparability of carbon disclosure, making ESG disclosure a stronger signal for investors in assessing corporate sustainability and business risk (Ibrahim, 2024).

The Effect of Green Innovation on Carbon Emission Disclosure

The findings show that green innovation does not significantly affect carbon emission disclosure, which is consistent with the study by (Li et al., 2023). However, other studies argue that green innovation can encourage environmental transparency and improve carbon disclosure practices (Aini & Wilasittha, 2026). Based on Signal Theory, companies implementing green innovation should provide positive environmental signals to

stakeholders. Nevertheless, companies may avoid disclosing carbon information because of high signaling costs and the perception that the market does not sufficiently reward such disclosures (Fitriana & Amelia, 2024). As a result, green innovation and carbon disclosure still operate separately in practice.

The Effect of ESG Disclosure on Carbon Emission Disclosure

The results demonstrate that ESG disclosure has a positive and significant effect on carbon emission disclosure, supporting the findings of (Lee & Kim, 2021). However, other studies argue that high ESG disclosure does not always reflect high-quality carbon transparency because of possible greenwashing practices (Siddique et al., 2026). According to Signal Theory, companies use ESG disclosure to communicate environmental commitment and reduce information asymmetry. The findings also indicate that companies increasingly recognize carbon disclosure as an important component of sustainability reporting, although disclosure practices may still be influenced by strategic and reputational motives (Harnida et al., 2023; Ibrahim, 2024).

The empirical findings indicate that within the Indonesian energy sector, investors respond favorably to overall ESG disclosures, yet remain indifferent toward specific green innovation initiatives and carbon emission disclosures. This phenomenon can be contextualized through the lens of the Indonesian regulatory and market landscape. The significant positive impact of ESG disclosure on firm value is heavily driven by the Financial Services Authority (OJK) regulation POJK No. 51/2017, which mandates sustainability reporting. Compliance with this regulation signals institutional stability and opens access to green funds, such as the IDX ESG Leaders index, thereby driving up market valuation.

In contrast, the insignificance of green innovation can be attributed to the short-term profit orientation prevalent among investors in the Indonesian capital market. Green innovation requires substantial upfront capital expenditure with prolonged payback periods, which investors often perceive as an immediate cost burden rather than a long-term asset, especially given the immature pricing ecosystem for renewable energy in the country. Furthermore, carbon emission disclosure fails to influence firm value because the practical implementation of carbon taxation in Indonesia has faced repeated delays. Consequently, in the absence of imminent financial penalties or strictly enforced carbon liabilities, investors treat carbon disclosure as non-material information that does not warrant adjustments to their valuation models.

4. CONCLUSION

This study assessed how Green Innovation and ESG Disclosure drive Firm Value, with CED acting as a mediator. The results show that Green Innovation has no significant impact on Firm Value or CED, indicating that investors in developing markets do not yet heavily reward eco-innovation. On the other hand, ESG Disclosure significantly enhances both Firm Value and CED, proving that broader transparency builds market trust and corporate reputation. Notably, CED fails to mediate the paths from Green Innovation and ESG Disclosure to Firm Value. This underscores that investors depend more on overarching ESG frameworks than specific carbon emission reports when pricing companies and gauging sustainability performance.

This research is subject to several limitations, such as a constrained observation window, a narrow selection of variables, and an exclusive dependence on secondary data drawn from annual and sustainability reports, which may contain subjective disclosure practices. In addition, the absence of standardized carbon reporting may reduce the comparability and credibility of disclosure information across companies. Accordingly, it is recommended that future investigations extend the sample horizon and introduce supplementary variables to provide deeper insights related to financial and environmental performance, and expand the research sample across different industrial sectors to obtain more comprehensive results regarding sustainability practices and firm value.

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