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GREENHOUSE GAS DISCLOSURE, ENVIRONMENTAL PERFORMANCE, AND FIRM VALUE: EVIDENCE FROM INDONESIAN MINING FIRMS

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Abstract

This study examines the effect of greenhouse gas emission disclosure and environmental performance on firm value from the perspective of signaling theory. The research focuses on mining companies listed on the Indonesia Stock Exchange during the 2021–2024 period. Firm value is proxied by Tobin's Q, greenhouse gas emission disclosure is measured using a content analysis–based disclosure index, and environmental performance is represented by the PROPER rating. Panel data are analyzed using multiple linear regression. The results indicate that greenhouse gas emission disclosure has a positive and significant effect on firm value, suggesting that emission disclosure serves as a credible sustainability signal for investors. In contrast, environmental performance measured through PROPER does not significantly affect firm value, indicating that compliance-based environmental indicators have limited signaling power in capital markets. Financial control variables, including profitability, leverage, and firm size, function as control factors in explaining firm value. This study contributes to the signaling theory literature by highlighting that different types of environmental signals possess varying strengths in influencing firm value, particularly in the context of emerging capital markets. The findings also provide insights for managers and regulators regarding the importance of enhancing quality of environmental disclosure beyond minimum regulatory compliance.

INTRODUCTION

Firm value is a key indicator that reflects market perceptions of a company's performance, prospects, and long-term sustainability. In the context of capital markets, firm value is influenced not only by financial performance but also by the quality of non-financial information disclosed to investors, particularly information related to environmental and sustainability aspects. As global investors' attention to climate change issues increases, environmental transparency has become an important factor influencing investment decision-making and firm valuation (Connelly et al., 2011). The relevance of environmental information to firm value becomes even more critical when companies operate in sectors with high environmental risk intensity, such as the mining sector.

The mining sector is among the industries with the highest levels of greenhouse gas (GHG) emissions and significant environmental risks, placing it under stricter regulatory pressure and public scrutiny. In Indonesia, increasing demands for environmental transparency

are reinforced through various regulations, including mandatory sustainability reporting and emission control policies. In this context, GHG emission disclosure and environmental performance serve as important signals used by companies to communicate their sustainability commitment and environmental risk management to the market (Delmas et al., 2013; Clarkson et al., 2019). These regulatory pressures and public scrutiny transform environmental disclosure from merely a compliance obligation into a signaling instrument for investors.

Based on signaling theory, firms can use environmental information disclosure as a signal to reduce information asymmetry between management and investors. Credible signals are expected to enhance market confidence and positively affect firm value (Spence, 1973; Connelly et al., 2011). GHG emission disclosure, in particular, is viewed as a signal of transparency and corporate readiness to address transition risks toward a low-carbon economy. Investors tend to perceive firms that openly disclose emissions as more responsible, adaptive, and long-term oriented entities (Matsumura et al., 2014). The effectiveness of such signals largely depends on how the market interprets the costs, credibility, and economic consequences of the disclosure.

However, the effectiveness of environmental signals is not always homogeneous. GHG emission disclosure may be perceived differently by the market depending on its quality, completeness, and associated cost implications. In certain circumstances, such disclosure may be interpreted as an indication of increased compliance costs and operational risks, which can potentially suppress firm value (Matsumura et al., 2014; Putri et al., 2024). This suggests that the relationship between GHG emission disclosure and firm value remains contextual and not yet fully conclusive. Divergent market perceptions of emission disclosure are reflected in empirical findings that continue to produce mixed results.

Empirical inconsistencies are also evident in prior studies. Several studies find that GHG emission disclosure has a positive effect on firm value (Anggraeni, 2015; Kurnia et al., 2021; Toly et al., 2019; Widagdo et al., 2023; Yong et al., 2022). In contrast, other studies report no significant effect or even a negative effect, as emission disclosure is perceived as an additional cost burden and risk (Asyifa & Burhany, 2022; Agatha & Titik Aryati, 2024; Pradnyawati & Werastuti, 2024; Putri et al., 2024). These differing results indicate variations in the perceived strength of emission disclosure signals among investors. Beyond GHG emission disclosure, another environmental signal commonly considered by investors is corporate environmental performance.

Environmental performance is used as an indicator of a firm's commitment to sustainability. In Indonesia, environmental performance is generally measured using the Corporate Performance Rating Assessment Program in Environmental Management (PROPER). Although PROPER provides relevant information regarding firms' environmental compliance, it is compliance-based in nature and has limitations in distinguishing the quality of environmental performance across firms. As a result, regulatory compliance–based environmental performance signals may be perceived as weak by investors and do not always lead to an increase in firm value (Ullmann, 1985; Widagdo et al., 2023;Septinurika et al., 2020). The compliance-oriented characteristics of environmental performance further influence how the market responds to such information.

Empirical findings on the relationship between environmental performance and firm value also show mixed results. Some studies find a positive effect of environmental performance on firm value (Anggraeni, 2015; Asyifa & Burhany, 2022; Toly et al., 2019), while others find no significant effect (Widagdo et al., 2023; Putri et al., 2024; Gawęda, 2025). These inconsistencies reinforce the argument that not all environmental signals possess the same informational value for the market. Nevertheless, investor decisions are influenced not only by environmental signals but also by firms' internal financial characteristics.

Internal financial characteristics function as fundamental signals for investors.

Profitability reflects a firm's ability to generate cash flows and is often associated with long-term performance prospects (Ross et al., 2017). Leverage represents the level of financial risk that may influence investor perceptions of firm stability (Frank & Goyal, 2007). Meanwhile, firm size is associated with visibility, legitimacy pressures, and disclosure capacity, such that larger firms tend to face higher transparency expectations, including in sustainability disclosure (Ullmann, 1985; Connelly et al., 2011). Accordingly, profitability, leverage, and firm size are employed as control variables to ensure that the effects of environmental signals on firm value are not distorted by fundamental financial factors. The interaction between sustainability signals and financial signals remains insufficiently explained in prior research.

Therefore, beyond empirical inconsistencies in prior findings, this study identifies a conceptual gap in the application of signaling theory within environmental disclosure research. Existing studies largely assume that sustainability-related information functions as a homogeneous signal in reducing information asymmetry, without sufficiently differentiating the underlying characteristics of various environmental signals. In particular, limited attention has been given to how differences in signal cost, voluntariness, and informational richness affect the market's interpretation of environmental information. As a result, the heterogeneous nature of environmental signals such as voluntary greenhouse gas emission disclosure versus compliance-based environmental performance remains underexplored. Addressing this conceptual limitation, this study positions both variables within the signaling theory framework to examine their relative signal strength in influencing firm value in Indonesia's mining sector.

In addition to addressing empirical inconsistencies, this study contributes to the refinement of signaling theory by distinguishing between the effectiveness of voluntary, high-cost sustainability signals and mandatory, low-cost compliance signals in an emerging market context. While signaling theory traditionally assumes that disclosed information functions uniformly as a signal to reduce information asymmetry, this study demonstrates that not all environmental signals are equally valued by the capital market. Greenhouse gas emission disclosure represents a voluntary and relatively costly signal, as it requires firms to incur reporting costs, expose potential environmental risks, and commit to greater transparency. In contrast, environmental performance measured through PROPER primarily reflects regulatory compliance, which is mandatory and entails relatively lower signaling costs. The empirical findings indicate that in Indonesia's mining sector characterized by high environmental risk and increasing sustainability scrutiny investors respond more strongly to voluntary disclosure-based signals than to compliance-based indicators. By empirically differentiating signal strength based on cost, voluntariness, and informational richness, this study extends signaling theory beyond its conventional homogeneous signal assumption and provides theoretical insight into how sustainability signals are interpreted in emerging capital markets characterized by high information asymmetry and institutional constraints.

Using data from mining companies listed on the Indonesia Stock Exchange during the 2021–2024 period, this study aims to analyze the effects of greenhouse gas emission disclosure and environmental performance on firm value. Practically, the findings are expected to provide implications for corporate management, investors, and regulators in improving the quality and effectiveness of environmental disclosure.

HYPOTHESIS DEVELOPMENT

Greenhouse Gas Emission Disclosure and Firm Value

Within the framework of signaling theory, firms face information asymmetry because management possesses more comprehensive information regarding risks and long-term prospects than investors. To reduce this asymmetry, firms can convey signals through the disclosure of relevant and credible information (Spence, 1973; Connelly et al., 2011). Greenhouse gas (GHG) emission disclosure represents a form of sustainability signal that

reflects a firm's readiness to manage climate-related risks, comply with environmental regulations, and demonstrate commitment to the transition toward a low-carbon economy. In this context, emission disclosure is not merely informative but also entails reporting costs and potential reputational risks, making such signals more credible to the market (Matsumura et al., 2014).

The reputational benefits of GHG emission disclosure are expected to outweigh the associated costs, particularly for firms operating in sectors with high environmental risk exposure, such as mining. Investors tend to perceive firms that are transparent about their emissions as entities with higher managerial quality, greater adaptability to regulatory pressures, and more stable long-term sustainability prospects (Griffin et al., 2017; Krüger, 2014). Accordingly, GHG emission disclosure is positioned as a relatively strong sustainability signal in influencing market perceptions of firm value.

Empirical evidence supports these theoretical arguments. Gabriel dan Toly (2019) demonstrate that carbon emission transparency enhances positive investor responses and is reflected in higher firm value. Similar findings are reported by Kurnia et al., (2021), who argue that emission transparency strengthens corporate reputation and increases market value. In addition, Anggraeni (2015), Widagdo et al., (2023) serta Yong et al., (2022) find that carbon emission disclosure is positively and significantly associated with firm value, as investors interpret such disclosure as a credible indicator of sustainability commitment. Based on these theoretical foundations and empirical evidence, the first hypothesis is formulated as follows:

H_1: Greenhouse gas emission disclosure has a positive effect on firm value.

Environmental Performance and Firm Value

In addition to emission disclosure, environmental performance is also viewed as a sustainability signal that reflects a firm's effectiveness in managing the ecological impacts of its operational activities. From a signaling theory perspective, strong environmental performance indicates management's ability to control environmental risks and meet stakeholder expectations regarding sustainable practices (Spence, 1973). In Indonesia, environmental performance is commonly measured using the Corporate Performance Rating Assessment Program in Environmental Management (PROPER), which evaluates firms' levels of compliance with environmental regulations.

However, PROPER represents a compliance-based performance measure, in which most firms strive to achieve minimum regulatory standards. This characteristic causes environmental performance signals to have lower differentiation power compared to voluntary and more information-rich emission disclosure signals (Ullmann, 1985; Delmas et al., 2013). Consequently, although environmental performance reflects regulatory compliance, the market may interpret this signal as relatively weak in distinguishing sustainability quality across firms.

Nevertheless, several empirical studies indicate that environmental performance still has the potential to influence firm value. Gabrielle dan Toly (2019) find that firms with higher PROPER ratings receive more positive market responses. Asyifa & Burhany (2022) also show that environmental performance contributes to enhanced corporate legitimacy and is reflected in market value. In addition, Anggraeni (2015) reports that firms' commitment to sustainable environmental management can increase investor confidence. Based on these theoretical arguments and empirical findings, environmental performance is expected to maintain a positive relationship with firm value, albeit with different signal strength compared to emission disclosure. Accordingly, the second hypothesis is formulated as follows:

H_2: Environmental performance has a positive effect on firm value.

Control Variables and Firm Value

In assessing firm value, investors consider not only sustainability signals but also

fundamental financial signals that reflect a firm's internal economic conditions. Profitability represents a firm's ability to generate cash flows and is often regarded as a primary indicator of long-term performance prospects (Ross et al., 2017). Firms with higher profitability tend to possess greater financial flexibility to allocate resources toward sustainability investments, which may influence market perceptions of firm value.

Leverage reflects a firm's financing structure and level of financial risk. High leverage can increase bankruptcy risk and weaken investor perceptions of firm stability, thereby potentially reducing firm value (Frank & Goyal, 2007). Meanwhile, firm size is associated with visibility, legitimacy pressures, and disclosure capacity. Larger firms tend to face higher transparency expectations and have more adequate resources to engage in sustainability disclosure (Ullmann, 1985; Connelly et al., 2011).

Accordingly, profitability, leverage, and firm size are employed as control variables in this study to isolate the effects of environmental signals on firm value. By controlling for these fundamental financial signals, hypothesis testing is expected to more accurately capture the relative effects of greenhouse gas emission disclosure and environmental performance on firm value.

The research framework of this study is presented as follows:

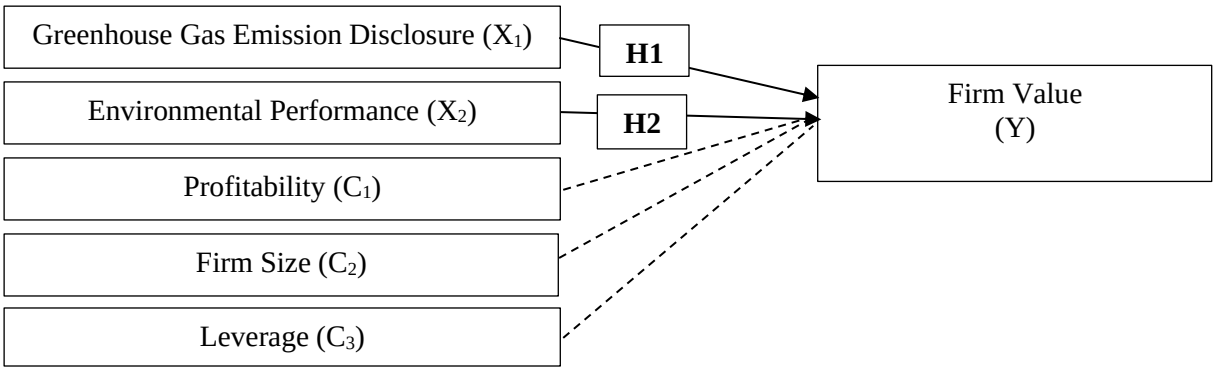

Figure 1.
Research Framework

RESEARCH METHODOLOGY

Research Design

This study employs a quantitative approach with a causal research design, aiming to examine the effects of greenhouse gas emission disclosure and environmental performance on firm value. The study is developed within the framework of signaling theory, which views environmental information disclosure as a signal conveyed by management to investors to reduce information asymmetry and shape market perceptions of corporate prospects (Spence, 1973; Connelly et al., 2011).

The research model incorporates control variables consisting of profitability (ROA), firm size (SIZE), and leverage (DER) to ensure that the relationship between environmental signals and firm value is not distorted by firms' fundamental financial characteristics. These control variables are selected because both theoretically and empirically they have been shown to function as financial signals influencing investors' assessments of firm value (Ross et al., 2017; Frank & Goyal, 2007).

Population and Sample

The research population includes all mining sector companies listed on the Indonesia Stock Exchange (IDX) during the 2021–2024 period. The mining sector is selected due to its

industry characteristics, which involve high environmental risk intensity, making emission disclosure and environmental performance particularly relevant signals for investors. The selection of the 2021–2024 observation period is academically justified by several contextual considerations. First, this period reflects the post-pandemic phase in which firms began to stabilize their operations and refocus on long-term sustainability strategies, including environmental transparency. Second, it coincides with the strengthening of sustainability-related regulations and reporting practices in Indonesia, such as the increasing adoption of sustainability reporting and heightened regulatory attention to greenhouse gas emission management. Third, the period captures recent market dynamics in which investors increasingly integrate environmental and climate-related information into firm valuation decisions. Therefore, the 2021–2024 period is considered relevant for examining the role of greenhouse gas emission disclosure and environmental performance as sustainability signals influencing firm value. The sampling method applied is purposive sampling, with sample selection criteria presented in Table 1.

Table 1.
Sample Selection Criteria

Sample Selection Criteria	Observations
Mining companies listed on the Indonesia Stock Exchange during 2021–2024	127
Companies that did not publish complete financial statements on the IDX or company websites	-37
Mining companies that did not issue sustainability reports during the observation period	-16
Companies that did not participate in the PROPER program organized by the Ministry of Environment and Forestry of the Republic of Indonesia	-41
Final sample	**33**
Total observations = 33 x 4	**132**

Source: Research Data, 2025

The selection criteria aim to ensure the availability of financial, sustainability, and environmental performance data that can be comprehensively analyzed (Asyifa & Burhany, 2022; Citraningtyas et al., 2025). However, the use of these criteria may introduce selection bias, as firms with lower environmental performance are more likely not to publish sustainability reports. The implications of this limitation are further discussed in the conclusion section.

Operational Definition and Measurement of Variables

Firm Value

Firm value is proxied using Tobin's Q, as this measure is able to capture market expectations of firm value more comprehensively than purely accounting-based indicators. Tobin's Q reflects investor perceptions of firms' long-term prospects and sustainability (Matthews et al., 2024; Pradnyawati & Werastuti, 2024).

$$\text{Tobin's Q} = \frac{\text{MVE + Total Debt}}{\text{Total Assets}}$$

Notes:
MVE: Market value of outstanding shares (number of shares outstanding × closing price)
Total Debt: Total liabilities of the firm
Total Assets = Total assets of the firm

Greenhouse Gas Emission Disclosure

Greenhouse gas emission disclosure is measured using the index developed by Choi et al., (2013) which consists of 18 disclosure items covering climate change risks, GHG emissions,

energy use, emission reduction strategies, and management accountability. Measurement is conducted through content analysis of annual reports and sustainability reports, assigning a score of 1 if an item is disclosed and 0 otherwise (Choi et al., 2013; Kurnia et al., 2021).

The content analysis process was conducted using a structured coding guideline based on the disclosure items developed by Choi et al., (2013). Each annual report and sustainability report was reviewed manually, and disclosure items were coded dichotomously (1 if disclosed and 0 otherwise). The coding was primarily conducted by one researcher, followed by a cross-checking process to ensure consistency and reduce potential subjectivity in item interpretation. Although formal inter-coder reliability statistics were not calculated, this approach is commonly applied in environmental disclosure studies and allows for consistent identification of disclosure practices. Nevertheless, the use of a single primary coder may still involve subjectivity, which represents a methodological limitation and an avenue for future research to employ multiple coders and inter-coder reliability testing.

$$GHG\_DISC = \frac{\sum Di}{18}$$

Notes:
GHG_DISC : Greenhouse Gas Emission Disclosure Index
∑Di : Number of disclosed items (1 = disclosed, 0 = not disclosed)
18 : Total number of items in the Choi index

The list of disclosure items is presented in Table 2 (Carbon Emission Disclosure Index). This content analysis method follows common empirical practices in environmental disclosure research, although limitations related to coding reliability remain an agenda for future research.

Table 2.
Carbon Emission Disclosure Index

Category	Item	Description	Score
Climate Change: Opportunities and Risks	CC_1	Assessment/description of climate change risks, both physical and regulatory, and actions taken or planned to manage these risks.	1
	CC_2	Assessment/description of current and future financial impacts, business impacts, and climate change prospects.	1
Greenhouse Gas Emissions	GHG_1	Methods used to calculate greenhouse gas emissions (e.g., ISO or GHG Protocol).	1
	GHG_2	External verification of the amount of greenhouse gas emissions and whether such verification exists and on what basis.	1
	GHG_3	Total greenhouse gas emissions (metric tons of CO_2-e emitted).	1
	GHG_4	Disclosure of Scope 1, Scope 2, or Scope 3 greenhouse gas emissions.	1
	GHG_5	Disclosure of greenhouse gas emissions by source (e.g., coal, electricity, etc.).	1
	GHG_6	Disclosure of greenhouse gas emissions based on facility or segment level.	1
	GHG_7	Evaluation of greenhouse gas emissions compared to previous years.	1
Energy Use	EC_1	Total energy consumption.	1
	EC_2	Amount of energy consumed from renewable sources.	1
	EC_3	Disclosure by type, facility, or segment.	1
Emission Reduction and	RC_1	Details of strategies/plans to reduce greenhouse gas emissions.	1

Category	Item	Description	Score
Costs	RC_2	Details of current greenhouse gas emission reduction targets and future targets.	1
	RC_3	Current emission reductions and costs or savings achieved from emission reduction plans.	1
	RC_4	Estimated future funds in the process of capital expenditure preparation.	1
Carbon Emission Accountability Analysis	ACC_1	Indication of a board committee (or other executive body) with overall responsibility for climate change-related actions.	1
	ACC_2	Description of the process used by the board or other executive body to assess the company's progress regarding climate change.	1
			18

Source : Choi,Lee, & Psaros (2013)

Environmental Performance

Environmental performance is proxied using the Corporate Performance Rating Assessment Program (PROPER) issued by the Ministry of Environment and Forestry. PROPER is classified into five color categories, which are subsequently converted into numerical scores ranging from 1 to 5 for statistical analysis purposes (Toly et al., 2019; Asyifa & Burhany, 2022).

The use of PROPER as a proxy for environmental performance reflects compliance-based environmental performance, emphasizing firms' levels of compliance with environmental regulations. Although ordinal in nature, treating PROPER as a numerical score follows prior research practices and enables quantitative analysis of the relationship between environmental performance and firm value (Citraningtyas et al., 2025). The PROPER measurement scheme is presented in Table 3.

Although PROPER is inherently ordinal in nature, its transformation into a numerical scale is intended to capture relative differences in environmental compliance levels across firms rather than to imply equal interval distances between categories. This approach is widely adopted in prior empirical studies examining environmental performance and firm value in Indonesia, particularly when PROPER functions as a compliance-based indicator rather than a precise performance metric. Consequently, the numerical treatment of PROPER in this study should be interpreted as an approximation of environmental performance ranking, not as a continuous measurement of environmental quality.

Table 3.
PROPER Measurement

Score	Description
5	Gold rating
4	Green rating
3	Blue rating
2	Red rating
1	Black rating

Source : Toly et al, (2019)

Control Variables

This study employs three control variables: profitability (ROA), which measures firms' ability to generate earnings from assets and serves as a fundamental financial performance signal (Agatha & Aryati, 2024), Firm size (SIZE) is included as a control variable to capture differences in firm scale, visibility, and disclosure capacity. Larger firms tend to face greater public scrutiny and legitimacy pressures, which may influence both their sustainability disclosure practices and market valuation (Ullmann, 1985; Connelly et al., 2011), dan Leverage (DER) measured by the natural logarithm of total assets; and leverage (DER), which reflects

firms' financing structure and financial risk level influencing sustainability investment flexibility (Kurnia et al., 2021).

ROA = Net Income/Total Assets
Size = Natural Logarithm (Total Assets)
Leverage (DER) = Total Debt/Equity

Data Collection Technique

This study utilizes secondary data in the form of financial statements, sustainability reports, and PROPER rating documents obtained from the official websites of the Indonesia Stock Exchange and the Ministry of Environment and Forestry. The use of secondary data enables data verification and enhances the reliability of empirical analysis (Kurnia et al., 2021; Agatha & Aryati, 2024).

Data Analysis Method

Data analysis is conducted using IBM SPSS Statistics version 23. The analytical methods include descriptive statistics, classical assumption tests, and multiple linear regression analysis. This approach remains commonly applied in accounting and sustainability research based on firm-level data in Indonesia (Ghozali, 2018).

It is important to acknowledge potential endogeneity concerns inherent in examining the relationship between sustainability disclosure and firm value, particularly the possibility of reverse causality. Firms with higher market valuation and stronger financial capacity may be more capable and willing to voluntarily disclose greenhouse gas emission information. Consequently, the observed association between emission disclosure and firm value may reflect not only investors' responses to sustainability signals but also the underlying characteristics of high-value firms.

Due to data availability constraints and the focus of this study on signalling effects rather than causal prediction, advanced econometric techniques such as instrumental variable estimation or dynamic panel models are not employed. Instead, this study adopts a pooled regression approach with the inclusion of key financial control variables profitability, leverage, and firm size to mitigate omitted variable bias and capture firms' fundamental economic conditions.

Accordingly, the findings of this study should be interpreted as associative rather than strictly causal. Despite this limitation, the results remain informative for understanding how different types of environmental signals are valued by investors in the Indonesian capital market, which is consistent with prior sustainability disclosure studies emphasizing signalling effects and market perception rather than causal inference.

Model Specification

This study employs a multiple linear regression model to examine the effects of greenhouse gas emission disclosure and environmental performance on firm value. The regression model is specified to capture the partial effect of each explanatory variable while controlling for firms' fundamental financial characteristics. Firm value, proxied by Tobin's Q, is modeled as a function of greenhouse gas emission disclosure, environmental performance, profitability, firm size, and leverage.

Although the dataset consists of firm-year observations, this study applies a pooled regression approach, assuming that the slope coefficients remain constant across firms and over time. This approach is commonly used in sustainability and accounting research when the primary objective is to examine the average relationship between disclosure-related variables and firm value (Ghozali, 2018). To mitigate potential bias arising from omitted firm-level characteristics, profitability, leverage, and firm size are included as control variables.

The regression model is estimated using Ordinary Least Squares (OLS). Prior to hypothesis testing, classical assumption tests are conducted to ensure the validity of the regression estimates. These include tests for normality, multicollinearity, heteroscedasticity, and autocorrelation. The regression coefficients are interpreted based on their sign, magnitude, and statistical significance at the 5 percent level.

Classical Assumption Tests

Classical assumption tests include normality testing (Kolmogorov–Smirnov), multicollinearity testing (VIF), heteroscedasticity testing (Glejser), and autocorrelation testing (Durbin–Watson), as recommended by Ghozali (2018) or multiple linear regression.

Hypothesis Testing

Hypothesis testing is conducted using multiple linear regression with the following model:

$$TQ_{it} = \beta_0 + \beta_1 GHG_{it} + \beta_2 EP_{it} + \beta_3 ROA_{it} + \beta_4 SIZE_{it} + \beta_5 DER_{it} + \varepsilon_{it}$$

Notes:
TQ = Firm Value
$\beta_0, \beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ = Regression coefficients
GHG = Greenhouse Gas Emission Disclosure
EP = Environmental Performance
ROA = Profitability
SIZE = Firm Size
DER = Leverage
ε = Error
i = Firm *i* in the sample
t = Year *t* during the research period (2021–2024).

Simultaneous tests (F-test), partial tests (t-test), and the coefficient of determination (R^2) are employed to evaluate the strength and significance of the effects of independent variables on firm value.

Although the dataset consists of firm-year observations, this study employs a pooled regression approach. This methodological choice is aligned with the study's primary objective of examining the signaling role of environmental information rather than establishing strict causal relationships. Pooled regression allows the analysis to focus on cross-sectional variation in sustainability signals across firms, while controlling for key firm-specific financial characteristics through the inclusion of profitability, firm size, and leverage. This approach is consistent with prior sustainability disclosure studies that emphasize market perception and associative relationships in emerging market contexts.

RESEARCH RESULTS AND DISCUSSION

Research Results

Using purposive sampling on mining sector companies listed on the Indonesia Stock Exchange (IDX) during the 2021–2024 period, this study obtained 132 firm-year observations based on specific selection criteria. The descriptive statistics in this study include greenhouse gas emission disclosure and environmental performance as independent variables, firm value as the dependent variable, and profitability, leverage, and firm size as control variables. Table 4 presents the results of the descriptive statistical analysis.

Descriptive Statistics and Environmental Performance Distribution

Descriptive statistics provide an overview of the data distribution, including minimum, maximum, mean, and standard deviation values. The complete results are presented in Table 4**.**

Table 4.
Descriptive Statistics Analysis

Variabel	N	Min	Max	Mean	Std. Deviation
Firm Value	132	0.11	12.92	1.4861	1.75884
GHG Emission Disclosure	132	0.11	1.00	0.7605	0.18963
Environmental Performance	132	1.00	5.00	3.3712	0.92798
Profitability	132	-0.54	0.59	0.0930	0.14621
Leverage	132	0.00	5.65	1.1356	1.13523
Firm Size	132	26.81	32.76	30.2079	1.41714

Source: Research Data, 2025

Table 5.
Frequency Distribution of Environmental Performance

Proper	Frequency	Valid Percent	Cumulative Percent
Black	2	1.5	1.5
Red	22	16.7	18.2
Blue	46	34.8	53.0
Green	49	37.1	90.2
Gold	13	9.8	100.0
Total	132	100.0	

Source: Research Data, 2025

Based on Table 4, firm value proxied by Tobin's Q has an average value of 1.4861, indicating that, on average, mining companies in the sample have market values exceeding their book values. However, the minimum value of 0.11 and the maximum value of 12.92 indicate a wide dispersion in market valuation across firms. This variation reflects heterogeneity in firm characteristics and differences in investor perceptions regarding risk and long-term prospects.

Greenhouse gas emission disclosure shows a mean value of 0.7605, indicating that most firms disclose a substantial proportion of emission-related items. Nevertheless, the minimum value of 0.11 suggests that some firms still exhibit very low levels of emission transparency. This variation reflects differences in corporate commitment to environmental information disclosure and may result in varying strengths of environmental signals in the capital market.

The frequency distribution of environmental performance in Table 5 indicates that most firms fall within the Blue (34.8%) and Green (37.1%) ratings, suggesting that the majority of companies meet minimum environmental management standards, with a smaller proportion exceeding them. In contrast, the proportion of firms achieving the gold rating remains relatively small (9.8%), while some firms still receive Red and Black ratings. This distribution pattern indicates that variations in environmental performance are largely dominated by regulatory compliance levels.

The dominance of blue and green ratings suggests that most firms fall within the category of compliance-based environmental performance. In the context of market valuation, this condition may limit the ability of environmental performance to serve as a strong signal for investors, as differences across performance categories are insufficient to create significant firm value differentiation.

Regarding control variables, average profitability (ROA) is relatively low at 0.0930, reflecting the capital-intensive nature of the mining industry and its sensitivity to commodity price fluctuations. The average leverage of 1.1356 indicates firms' reliance on debt financing,

while firm size appears relatively homogeneous, reflecting the dominance of large-scale firms within the mining sector.

Classical Assumption Test Results

The normality test was conducted to assess whether the data meet the assumption of normal distribution required for further analysis. The results of this test are presented in Table 6**.**

Table 6.
Normality Test Result

N	132
Asymp.Sig. (2-tailed)[c]	0.041

Source: Research Data, 2025

The normality test using the One-Sample Kolmogorov–Smirnov test indicates that the regression residuals are not normally distributed, with a significance value of 0.041, which is below the 0.05 threshold. This result suggests a violation of the normality assumption.

As a diagnostic step, case wise diagnostics were conducted to identify potential extreme observations affecting the residual distribution. However, subsequent analysis retained the original data to maintain sample consistency and avoid potential bias from data exclusion.

Although the normality assumption is not fully satisfied, this condition does not undermine the validity of the regression estimates due to the relatively large sample size (n = 132). According to the Central Limit Theorem, with an adequate sample size, the distribution of regression coefficient estimates tends to approximate normality even when residuals are not perfectly normally distributed. Therefore, the regression model remains appropriate for hypothesis testing.

Table 7.
Multicollinearity Test Results

Variable	Tolerance	VIF
GHG Emission Disclosure	0.681	1.468
Environmental Performance	0.748	1.336
Profitability	0.782	1.278
Leverage	0.764	1.309
Firm Size	0.599	1.669

Source: Research Data, 2025

The multicollinearity test results presented in Table 7 show that all independent variables have tolerance values above 0.10 and Variance Inflation Factor (VIF) values below 10. These findings indicate the absence of high linear correlations among independent variables. Accordingly, the regression model does not suffer from multicollinearity issues that could compromise coefficient stability, allowing each variable's partial effect on firm value to be interpreted reliably.

Table 8.
Heteroscedasticity Test Results

Model	Sig
(Constant)	0.676
GHG Emission Disclosure	0.054
Environmental Performance	0.063
Profitability	0.055
Leverage	0.488
Firm Size	0.484

Source: Research Data, 2025

The Glejser test results in Table 8 indicate that, in the initial model, some variables exhibited significance values below 0.05, suggesting the presence of heteroscedasticity. To address this issue, data transformation using the natural logarithm (LN) was applied. After transformation, all variables show significance values above 0.05, indicating that residual variance has become homogeneous. Therefore, the transformed regression model no longer exhibits heteroscedasticity and is suitable for further analysis.

Table 9.
Autocorrelation Test Results

Model	Std. Error of the Estimate	Durbin-Watson
1	0.53964	1.848

Source: Research Data, 2025

The autocorrelation test using the Durbin–Watson statistic indicates a value of 1.848, which exceeds the lower bound (dL = 1.7950) and is close to 2. This result suggests the absence of both positive and negative autocorrelation in the regression model. Accordingly, residuals are independent across observations, satisfying the no-autocorrelation assumption.

Hypothesis Testing

Table 10.
Multiple Linear Regression Results

Model	Unstandardized Coefficients		Standardized Cefficients	t	Sig.
	B	Std. Error	Beta		
(Constant)	4.350	4.491		0.969	0.335
GHG Emission Disclosure	0.315	0.172	0.171	2.830	0.020
Environmental Performance	0.037	0.170	0.019	0.217	0.828
Profitability	0.235	0.043	0.495	5.501	0.000
Leverage	0.164	0.055	0.271	3.002	0.003
Firm Size	-1.052	1.321	-0.078	-0.796	0.428
R Square	0.233				
Adjusted R Square	0.198				
F	6.683				
F.Sig	0.000				

Source: Research Data, 2025

The multiple linear regression results presented in Table 10 indicate that the regression model used in this study is simultaneously significant. The F-statistic value of 6.683 with a significance level of 0.000, which is lower than 0.05, demonstrates that all independent variables and control variables jointly have a significant effect on firm value.

The Adjusted R Square value of 0.198 indicates that 19.8% of the variation in firm value can be explained by greenhouse gas emission disclosure, environmental performance, profitability, leverage, and firm size, while the remaining 80.2% is explained by other factors outside the research model. Although the adjusted R^2 value indicates that the explanatory power of the model is relatively moderate, this condition is common in firm value studies, particularly in environmentally sensitive and capital-intensive industries such as mining. Firm value in the mining sector is strongly influenced by external factors beyond firm-level characteristics, including commodity price volatility, geopolitical risk, global demand fluctuations, and uncertainty in energy transition policies. These macro-level factors tend to dominate market valuation and are difficult to capture within firm-level regression models. Therefore, the relatively low adjusted R^2 does not undermine the validity of the regression results, but rather reflects the complex and multifactorial nature of firm value determination in the mining industry.

Partially, the regression results show that greenhouse gas emission disclosure has a

positive regression coefficient of 0.315, with a t-value of 2.830 and a significance level of 0.020. This finding indicates that greenhouse gas emission disclosure has a significant effect on firm value.

In contrast, environmental performance has a regression coefficient of 0.037, with a t-value of 0.217 and a significance level of 0.828, indicating that environmental performance does not have a significant effect on firm value.

The control variables show mixed results. Profitability has a positive regression coefficient of 0.235, with a t-value of 5.501 and a significance level of 0.000, indicating a positive and significant effect on firm value. Leverage also shows a positive and significant effect, with a coefficient of 0.164, a t-value of 3.002, and a significance level of 0.003. Meanwhile, firm size has a negative regression coefficient of −1.052, with a t-value of −0.796 and a significance level of 0.428, indicating that firm size does not have a significant effect on firm value.

Discussion

Effect of Greenhouse Gas Emission Disclosure on Firm Value

The regression results indicate that greenhouse gas emission disclosure has a positive and significant effect on firm value, as proxied by Tobin's Q. The positive regression coefficient with a significance level below 0.05 suggests that the more extensively firms disclose their greenhouse gas emissions, the higher their firm value as reflected in market valuation.

This finding is consistent with the descriptive statistical analysis, which shows that the level of greenhouse gas emission disclosure is relatively high, with a mean value of 0.7605. This condition indicates that most mining companies in the sample disclose emission-related information to a considerable extent, although variations in transparency still exist across firms. Such variation allows the market to respond differently to the quality of emission disclosure provided by individual firms.

From a signaling theory perspective, greenhouse gas emission disclosure functions as a credible sustainability signal because it involves reporting costs and potential reputational risks if the disclosed information does not align with firms' actual practices. This signal provides investors with additional information regarding firms' commitment to environmental risk management and long-term sustainability, thereby reducing information asymmetry between management and external stakeholders.

The findings of this study are consistent with prior research showing that greenhouse gas emission disclosure has a positive effect on firm value (Anggraeni, 2015; Kurnia et al., 2021; Toly et al., 2019; Widagdo et al., 2023; Yong et al., 2022). The consistency of these results strengthens the argument that capital markets respond positively to voluntary and informative environmental transparency. This positive effect remains robust after the inclusion of profitability, leverage, and firm size as control variables, indicating that greenhouse gas emission disclosure makes an independent contribution to firm value, beyond firms' financial characteristics.

Effect of Environmental Performance on Firm Value

In contrast to greenhouse gas emission disclosure, the regression results show that environmental performance proxied by PROPER ratings does not have a significant effect on firm value. Although the regression coefficient is positive, it is not statistically significant, indicating that differences in environmental performance levels are not sufficiently strong to influence market valuation.

This result is consistent with the descriptive analysis and frequency distribution of environmental performance, which show that most firms fall within the Blue and Green ratings.

This condition suggests that the majority of firms operate at minimum compliance levels or only slightly exceed them. The relatively small proportion of Gold-rated firms limits variation in environmental performance across firms. In the context of capital markets, this limited variation reduces the ability of environmental performance signals to significantly differentiate firm value.

From a signaling theory standpoint, PROPER-based environmental performance represents a compliance-based signal with relatively low differentiation power in the eyes of investors. Investors tend not to sharply distinguish between firms with Blue and Green ratings, as both primarily reflect regulatory compliance rather than environmental excellence beyond compliance. Consequently, environmental performance information has not yet been perceived as a strategic signal relevant to firm value formation.

These findings are consistent with previous studies reporting that environmental performance does not have a significant effect on firm value (Widagdo et al., 2023; Putri et al., 2024; Gawęda, 2025). Therefore, the insignificance of environmental performance in this study does not indicate a weakness of the research model but rather reflects the limitations of compliance-based indicators as market signals capable of economically differentiating firm value.

Role of Control Variables in the Model

The control variables indicate that profitability has a positive effect on firm value, reflecting that financial performance remains a primary consideration for investors when evaluating mining companies. Leverage and firm size do not exhibit significant effects, suggesting that financing structure and firm scale are not dominant determinants of firm value during the observation period.

The results related to the control variables provide further insight into the interaction between financial signals and environmental signals in shaping firm value. Profitability and leverage function as strong financial signals that convey immediate information regarding firms' cash-generating ability and financial risk exposure. When these financial signals are salient, they may either reinforce or dominate sustainability signals in investors' valuation decisions. In the mining sector, where earnings volatility and capital structure risks are substantial, investors tend to prioritize profitability and leverage as primary valuation anchors. Consequently, sustainability signals particularly those based on compliance such as environmental performance may be partially overshadowed and not fully capitalized into firm value. This interaction helps explain why greenhouse gas emission disclosure, as a more voluntary and information-rich signal, remains valued by the market, while compliance-based environmental performance does not consistently translate into higher firm value.

This study contributes to the advancement of signalling theory by demonstrating that environmental signals are not homogeneous in their ability to influence firm value. The findings indicate that voluntary greenhouse gas emission disclosure functions as a stronger signal to the capital market than compliance-based environmental performance indicators such as PROPER ratings. This distinction highlights those investors place greater value on signals that involve higher disclosure costs, greater managerial discretion, and higher credibility.

From a signalling theory perspective, voluntary emission disclosure represents a costly signal that is more difficult to imitate by low-performing firms, thereby enhancing its informativeness and reliability. In contrast, environmental performance signals based on regulatory compliance tend to be standardized and symbolic, reducing their ability to differentiate firms in the eyes of investors. This study therefore refines signalling theory by emphasizing the importance of signal characteristics such as voluntariness, costliness, and discretion in determining market responses to sustainability-related information.

By providing empirical evidence from the Indonesian mining sector, an emerging

market characterized by high environmental risk and regulatory pressure, this study extends signalling theory beyond its traditional financial context. The results underscore that sustainability-related signals operate under different institutional conditions, where market participants selectively value signals that convey credible long-term environmental commitment rather than mere regulatory adherence.

CONCLUSION

This study demonstrates that greenhouse gas emission disclosure has a positive effect on firm value. This finding indicates that increased transparency in disclosing greenhouse gas emissions enhances investor confidence and provides a positive signal regarding firms' commitment to sustainability. In contrast, environmental performance measured using PROPER ratings does not have a significant effect on firm value. This suggests that although firms obtain certain environmental ratings, such ratings are not yet sufficiently influential to affect market valuation. This is particularly the case because most firms in the sample remain at minimum compliance levels. Consequently, environmental performance signals received by the market are not yet strong enough to be internalized into firm value.

Conversely, leverage and profitability are found to have positive and significant effects on firm value. These findings indicate that firms' ability to generate profits and effectively manage debt-based financing structures remains a primary factor valued by investors. Meanwhile, firm size does not have a significant effect on firm value, suggesting that the magnitude of a firm's assets does not automatically determine its market valuation.

From a policy perspective, the findings suggest that regulators should move beyond encouraging general environmental compliance toward promoting more standardized, quantitative, and comparable greenhouse gas emission disclosures. Regulatory bodies such as the Financial Services Authority (OJK) and the Ministry of Environment and Forestry may consider strengthening disclosure guidelines by requiring firms to report emission data using consistent measurement frameworks, such as scope-based emissions and reduction targets, rather than relying predominantly on symbolic or compliance-oriented indicators. While the PROPER program remains important as a baseline assessment of regulatory compliance, it may be complemented with more information-rich disclosure standards to enhance its relevance for capital market participants. Such policy direction would improve the credibility and decision-usefulness of environmental information for investors and facilitate more efficient market valuation of corporate sustainability performance.

This study is subject to limitations related to its sample scope, which focuses solely on mining sector firms, as well as the relatively limited observation period. Additionally, treating PROPER as a numerical variable may not fully capture its ordinal and compliance-based nature. Therefore, future research is encouraged to expand sample coverage and extend the research period. To provide a more comprehensive understanding of the determinants of firm value, future studies may incorporate additional factors such as emission intensity, environmental risk, corporate governance quality, or other sustainability-related indicators. For investors, greenhouse gas emission disclosure and firms' financial performance may serve as more relevant indicators than compliance-based environmental performance when assessing firm value and long-term prospects.

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