

Analysis of Costs and Environmental Performance on the Valuation of Mining Companies, with Business Scale as a Moderating Variable

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ABSTRACT

Purpose: This study aims to analyze the impact of environmental costs and environmental performance on firm valuation, with firm size as a moderating variable, among mining companies in Indonesia.

Research Method: This study employs a quantitative approach using panel data regression analysis (Fixed Effects Model) and Moderated Regression Analysis (MRA). Secondary data were obtained from financial statements, annual reports, sustainability reports, and PROPER ratings of mining companies listed on the Indonesia Stock Exchange for the period 2021–2024. The sample was selected using purposive sampling based on predetermined criteria.

Results and Discussion: The results of the study indicate that environmental costs and firm size have a significant negative effect on firm valuation, while environmental performance has no significant effect. Furthermore, firm size does not moderate the relationship between environmental costs or environmental performance and firm valuation.

Implications: These findings highlight the importance of improving the quality of environmental information implementation and disclosure to support decision-making and strengthen sustainability reporting standards.

Originality: The novelty of this study lies in its examination of the moderating role of company size in the relationship between environmental costs, PROPER-based environmental performance, and firm valuation among Indonesian mining companies during the 2021–2024 period.

Keywords: environmental costs; environmental performance; company valuation; business scale; PROPER.

1. Introduction

Indonesia's mining sector faces a fundamental paradox: on the one hand, it is an essential pillar of economic growth; on the other hand, it has the potential to trigger environmental degradation and social conflict if its operations are not managed in accordance with sustainability principles. This reality is evident in various environmental incidents that have drawn public attention, such as repeated coal spills polluting the sea in the Meureubo Marine Conservation Area (KKL) in West Aceh, ecosystem damage caused by nickel mining operations on Obi Island in North Maluku, and growing concern over mining activities in the UNESCO Raja Ampat Global Geopark. These phenomena indicate that the success of mining companies is no longer measured solely by economic achievements but also by their

ability to manage environmental impacts responsibly, thereby gaining acceptance from the public, regulators, and other stakeholders.

From the perspective of Legitimacy Theory, companies strive to maintain social legitimacy by aligning their operations with society's expected values (Al Bukhori & Sisdianto, 2025). When mining activities cause significant environmental impacts, a company's legitimacy may decline, thereby motivating it to improve its environmental management practices—including through environmental expenditures and improved environmental performance. Thus, this theory positions environmental costs and environmental performance as instruments for maintaining a company's social legitimacy, rather than as mechanisms that directly influence capital market responses. Meanwhile, Signaling Theory offers a different perspective, framing environmental information as a signal companies convey to investors and other market participants. Disclosures of environmental costs and performance are expected to reduce information asymmetry about a company's sustainability risks, thereby influencing investors' evaluation of the company (Saputri *et al.*, 2023). Therefore, Legitimacy Theory is used in this study to explain companies' motivations to improve environmental management practices. In contrast, Signaling Theory explains how such information can influence corporate valuation through capital market mechanisms.

Research on the factors influencing corporate valuation has expanded significantly, focusing on both financial indicators and corporate sustainability aspects. In recent years, attention to environmental factors has grown alongside the rise of Environmental, Social, and Governance (ESG) practices and increasing demands for transparency regarding the environmental impacts of corporate activities. These conditions have spurred research examining whether information on environmental costs and performance has value relevance for corporate valuation (Altarawneh *et al.*, 2025; Mumtazah & Purwanto, 2020; Nuzula, 2021). Several studies report that environmental performance sends a positive signal to the market, thereby increasing corporate valuation. Research by Mardiana & Wuryani (2019), Wahidahwati & Ardini (2021), and Heryanti & Harahap (2025) indicates that companies with better environmental performance achieve higher valuations. These findings suggest that effective environmental management can be perceived as an indicator of better corporate governance and more adequate environmental risk management, thereby potentially increasing stakeholder confidence in the company's prospects.

Research on environmental costs also shows that corporate spending on environmental conservation activities can yield long-term economic benefits through improved corporate reputation, reduced environmental risks, and strengthened operational sustainability. Heryanti & Harahap (2025) found that environmental costs have a positive effect on corporate valuation, indicating that environmental investments, under certain conditions, can be viewed as part of a company's sustainability strategy. Although various studies have examined the relationships among environmental costs, environmental performance, and corporate valuation, the empirical results remain inconsistent and have not yet yielded conclusive findings on the relevance of environmental information to corporate value creation. Regarding the environmental performance variable, studies by Mardiana & Wuryani (2019), Wahidahwati & Ardini (2021), and Heryanti & Harahap (2025) indicate a significant positive effect on firm valuation. However, Mumtazah & Purwanto (2020) and Hidayat *et al.*, (2023) found that environmental performance did not have a significant effect. Similar inconsistencies were also found regarding the environmental cost variable. Heryanti & Harahap (2025) reported that environmental costs have a positive effect on firm valuation, whereas Saputra (2020) and Pohan (2022) found no

significant effect. In fact, Nuzula (2021) and Hidayat *et al.*, (2023) found a negative relationship between environmental costs and firm valuation. These differing findings indicate that the relationship between environmental information and firm valuation remains influenced by specific empirical conditions that previous research has not adequately explained.

This research gap suggests that the inconsistency in research results is likely caused not only by differences in sample characteristics or observation periods but also by contingent factors that influence how the market responds to a company's environmental information. One relatively under-examined factor is firm size, which reflects a company's resource capacity, financing capabilities, and the quality of its corporate governance in implementing environmental management strategies. Carandang & Ferrer (2020), Khan & Gupta (2025), and Veradine & Praptoyo (2024) explain that companies with a larger business scale generally have better financial resources, control systems, and disclosure capabilities. Hence, the implementation of environmental programs has the potential to be more credible compared to that of small-scale companies. However, the role of business scale as a moderating variable in the relationship between environmental costs, environmental performance, and firm valuation—particularly in Indonesia's mining sector—has not yet received adequate attention in the empirical literature.

Based on this gap, this study aims to analyze the effects of environmental costs and environmental performance on firm valuation and to test the role of firm size as a moderating variable for mining companies listed on the Indonesia Stock Exchange during the 2021–2024 period. The novelty of this study lies not only in the use of firm size as a moderating variable but also in the integration of the context of Indonesian mining companies, which are characterized by high environmental risk, the use of the 2021–2024 observation period, which reflects the latest developments in sustainability practices and ESG disclosure, and the utilization of environmental cost measurements based on annual reports and sustainability reports combined with environmental performance assessments using PROPER as an external indicator. Thus, this study is expected to provide an empirical contribution in explaining the conditions under which environmental information is relevant to corporate valuation while also enriching the development of Signal Theory in the context of environmental information disclosure in the Indonesian mining industry.

The remainder of this paper is organized as follows. Section 2 provides a literature review and hypothesis development. Section 3 presents the research method and design. Section 4 provides the results and discussion. Section 5 presents Concluding Remarks and Recommendations.

2. Literature Review and Hypothesis Development

2.1 Literature Review

2.1.1 Stakeholder Theory

Stakeholder Theory holds that a company's success is determined not only by its ability to generate profits for shareholders but also by its capacity to create value for all stakeholders, including the government, investors, employees, the community, customers, suppliers, and the environment. This theory emphasizes that every strategic decision a company makes must take into account the interests of various parties that can influence or be influenced by the company's activities. Thus, a company's objectives are not solely focused on achieving economic performance but also on building sustainable

relationships through responsible, transparent governance oriented toward creating long-term value (Freeman, 2023; Freeman & Menghwar, 2024).

Recent developments indicate that Stakeholder Theory is increasingly integrated with issues of sustainability, environmental responsibility, and Environmental, Social, and Governance (ESG) practices. The latest literature indicates that companies that accommodate their stakeholders' interests tend to have greater legitimacy, higher-quality information disclosure, and greater long-term competitiveness (Mahajan *et al.*, 2023). In the context of mining companies, this theory serves as a foundation for explaining that managing environmental costs, improving environmental performance, and utilizing corporate resources are part of an organization's strategy to meet stakeholder expectations while supporting an increase in corporate value (Chandra, 2025).

2.1.2 Legitimacy Theory

Legitimacy Theory holds that a company's survival depends heavily on its ability to obtain and maintain legitimacy in society by aligning its operations with prevailing social values, norms, and expectations. Legitimacy is viewed as a strategic resource because it determines the level of public acceptance of a company's existence, particularly in industries with high environmental impact, such as mining. Therefore, companies are encouraged to demonstrate social and environmental accountability through policies, sustainability practices, and transparent disclosure of information as part of their efforts to maintain a social license to operate (Meutia *et al.*, 2022; Moloi & Marwala, 2020). From this perspective, environmental management practices serve as an organizational mechanism to narrow the legitimacy gap—the disparity between public expectations and corporate actions.

Developments in the literature indicate that Legitimation Theory is increasingly used to explain sustainability reporting practices and environmental information disclosure in response to growing stakeholder demands for corporate accountability. L'Abate *et al.*, (2023) assert that sustainability disclosure is a key instrument for gaining social legitimacy, while Meutia *et al.*, (2022) demonstrate that legitimacy is one of the primary rationales for companies in communicating sustainability information. Furthermore, Sari *et al.*, (2025) emphasize that organizational legitimacy is built through harmonious relationships with the society and communities surrounding the company. In line with this, recent systematic reviews also indicate that Legitimacy Theory remains one of the primary conceptual frameworks for explaining corporate environmental and sustainability disclosures (Magalhães, 2026). In this study, Legitimacy Theory is used to explain how environmental costs and environmental performance constitute forms of corporate responsibility for obtaining and maintaining the social legitimacy that supports the company's operational sustainability.

2.1.3. Signaling Theory

Signaling Theory explains that companies can reduce information asymmetry between management and external parties by disclosing relevant, credible, and verifiable information. In the capital market, investors do not have equal access to a company's internal information; therefore, investment decisions are heavily influenced by signals published through financial statements and sustainability reports. Consequently, the disclosure of information on environmental costs, performance, and sustainability practices is viewed as a signal of the quality of corporate governance, a company's ability to manage risks, and its commitment to long-term sustainability. The more credible the information provided, the

greater its potential to reduce uncertainty and improve the quality of company assessments (Alghamdi & Agag, 2023; Friske *et al.*, 2023).

Recent research indicates that Signaling Theory is increasingly being used to explain the relevance of Environmental, Social, and Governance (ESG) information to corporate value. Sun *et al.*, (2025) demonstrate that ESG performance, reporting frameworks, and disclosure quality contribute to increased corporate value through the mechanism of information transmission to the market. These findings are supported by Abideen & Fuling (2024), who explain that sustainability reporting can influence investor sentiment when the information provided is deemed credible and consistent. Furthermore, Desai (2022) asserts that carbon disclosures serve as a form of corporate signaling to demonstrate environmental accountability, while Nguyen (2025) shows that corporate social responsibility disclosures increase corporate value through signaling mechanisms. In this study, Signaling Theory is used to explain that environmental costs and environmental performance constitute strategic information that can reduce information asymmetry and potentially influence firm valuation, with firm size positioned as a factor that can affect the strength of these signals.

2.1.4 Company Valuation

Firm value is an indicator that reflects the market's perception of a company's prospects, performance, and ability to create economic value on a sustainable basis. Firm value is influenced not only by financial performance but also by nonfinancial information related to governance, sustainability, and risk management. In financial research, firm value is generally measured using Tobin's Q, which is the ratio of a company's market value to the replacement cost of its assets, reflecting investors' expectations about the company's future growth potential. Compared to accounting-based ratios, Tobin's Q is considered better at capturing the market's response to information published by companies, including information regarding sustainability practices and environmental responsibility (Martini, 2024; Prabawati & Rahmawati, 2022).

Developments in the literature indicate that sustainability factors are increasingly becoming important determinants in corporate valuation. Friske *et al.*, (2023) explain that voluntary sustainability reporting can enhance firm value by reducing information asymmetry. Sun *et al.*, (2024) also found that ESG performance, the quality of the reporting framework, and the credibility of disclosures contribute to increased firm value. These findings are reinforced by Nguyen (2025), who demonstrates that disclosures regarding corporate social responsibility are relevant to increasing corporate value through the mechanism of information transmission to the market. In this study, corporate valuation is the dependent variable used to assess the extent to which environmental costs, environmental performance, and business scale influence the market's valuation of mining companies listed on the Indonesia Stock Exchange.

2.1.5 Environmental Costs

Environmental costs are all expenditures incurred by a company to prevent, control, reduce, and remediate environmental impacts arising from its operations. From an environmental accounting perspective, these costs are viewed not only as operating expenses but also as part of a strategic investment that supports the company's sustainability by improving resource efficiency, ensuring regulatory compliance, and managing environmental risks. Murti (2023) explains that environmental

cost accounting has evolved as a tool that helps companies identify, measure, and disclose environmental costs more accurately, thereby supporting sustainability-oriented decision-making. This perspective also underscores that risk management and sustainability expenditures are part of a company's strategic decisions and can generate long-term economic benefits (Hadjjah & Karmila, 2024). In line with this, Desai (2022) emphasizes that the disclosure of environmental costs and activities is a crucial aspect of corporate accountability in responding to growing demands for transparency and sustainable business practices.

Research developments indicate that environmental costs play an increasingly important role in creating corporate value through improved sustainability disclosures and environmental risk management. Anggraini & Kusuma (2024) found that environmental costs, carbon emissions disclosures, and environmental performance are correlated with corporate value. Widiyanti *et al.*, (2024) also demonstrated that disclosures of environmental costs contribute to increased profitability through improved environmental management practices. Furthermore, Anthoni & Cerya (2025) explain that implementing environmental accounting improves corporate performance by strengthening environmental governance and social responsibility. In this study, environmental costs are defined as corporate expenditures related to environmental management and protection, and their impact on corporate valuation in the mining sector is analyzed.

2.1.6 Environmental Performance

Environmental performance refers to a company's success in managing the environmental impacts of its operations through regulatory compliance, efficient resource use, pollution control, and the implementation of sustainable business practices. Environmental performance reflects a company's commitment to minimizing environmental risks while meeting stakeholder demands regarding social responsibility and sustainability. In the Indonesian context, environmental performance is generally measured using the Corporate Environmental Performance Rating Program (PROPER), administered by the Ministry of Environment and Forestry, as an external indicator of the quality of a company's environmental management. These findings align with research by Rasyid & Adi (2026), which shows that environmental performance is one of the factors that support an increase in corporate value through the implementation of more effective sustainability practices. Ermawati *et al.*, (2023) explain that good environmental performance contributes to increased corporate value by strengthening market confidence, while Muqorobin & Simamora (2025) demonstrate that it also enhances corporate value through improved profitability.

Research developments indicate that environmental performance is increasingly viewed as a key indicator in assessing corporate sustainability and the quality of corporate governance. Miranti *et al.*, (2025) found that environmental performance, together with green accounting practices, positively contributes to increased corporate value. These findings are reinforced by Salam *et al.*, (2025), who demonstrate that environmental performance and costs play a role in increasing corporate value through more effective environmental management. Furthermore, Salehah *et al.*, (2026) demonstrated that the adoption of green accounting and improvements in environmental performance increase corporate value. In this study, environmental performance is proxied using the PROPER rating because it objectively reflects a company's level of compliance and the quality of its environmental management, making it relevant for analyzing its impact on corporate valuation in the mining sector.

2.1.7 Firm Size

Firm size is a characteristic that reflects the extent of a company's operational capacity and resources. In financial research, company size is generally proxied by the natural logarithm of total assets (Ln Total Assets) because it reflects a company's ability to manage resources, secure financing, cope with business risks, and ensure business continuity. Larger companies generally have broader access to financing, stronger governance systems, and greater flexibility in implementing business and sustainability strategies. Fernandez and Pradana (2025) explain that firm size is a fundamental factor that increases firm value by strengthening the capital structure and profitability. In line with this, Estiasih *et al.*, (2024) state that firm size reflects an organization's capacity to manage assets and improve corporate performance sustainably.

Research developments indicate that firm size plays a crucial role in determining corporate value and the effectiveness of corporate strategy implementation. Handini & Susilo (2025) found that firm size has a positive effect on firm value because larger firms tend to have more adequate resources to improve performance and create value for investors. These findings are supported by Yunita *et al.*, (2025), who demonstrated that firm size increases firm value, with profitability serving as a reinforcing factor. Furthermore, Thahir (2026) also demonstrated that firm size is one of the key determinants of firm value, alongside leverage and profitability. In this study, firm size is proxied using the natural logarithm of total assets (Ln Total Assets). It is positioned as a moderating variable to test whether a firm's resource capacity can strengthen the relationship between environmental costs and environmental performance on firm valuation in the mining sector.

2.2 Hypothesis Development

2.2.1 The Impact of Environmental Costs on Corporate Valuation

According to Signaling Theory, companies can reduce information asymmetry by disclosing information that reflects their commitment to environmental management. Environmental expenditures are one indicator that a company is allocating resources to activities aimed at preventing, controlling, or mitigating environmental impacts. Such disclosures can signal a company's commitment to sustainability, though the effectiveness of this signal depends on how the market assesses the credibility of the information. Research by Altarawneh *et al.*, (2025) indicates that environmental disclosures are relevant to firm value, while Heryanti & Harahap (2025) found that environmental expenditures have a positive effect on firm value. These findings are supported by Carandang & Ferrer (2020), who demonstrated that environmental accounting practices contribute to improved corporate performance and market value. Based on these findings, this study hypothesizes that environmental costs may increase corporate valuation.

H1: *Environmental Costs Have a Positive Impact on Company Valuation.*

2.2.2 The Impact of Environmental Performance on Company Valuation

Legitimacy Theory explains that companies strive to obtain and maintain social legitimacy by aligning their operations with public expectations. In the mining industry, environmental performance reflects a company's ability to meet regulatory requirements and fulfill its responsibilities for the environmental impacts it causes. From the perspective of Signaling Theory, environmental performance achievements,

as revealed by indicators such as PROPER, can serve as signals that help reduce information asymmetry regarding the quality of a company's environmental management. Wahidahwati & Ardini (2021) demonstrate that environmental performance positively affects firm value, while Mardiana & Wuryani (2019) also find that companies with better environmental management tend to receive higher valuations. Based on this theoretical framework and prior studies, this research hypothesizes that environmental performance positively affects firm valuation.

H2: *Environmental Performance positively impacts Company Valuation.*

2.2.3 The Effect of Business Scale on Company Valuation

According to Stakeholder Theory, companies with greater resources generally have a better capacity to meet the needs of various stakeholders, including investors, regulators, the public, and the environment. A large scale of operations also reflects a company's ability to manage risk, maintain operational sustainability, and improve the quality of corporate governance. Research by Wahidahwati & Ardini (2021) shows that company size has a positive effect on firm value. Similar findings were reported by Ifada *et al.*, (2021), who stated that larger companies tend to have higher market valuations than smaller companies. Based on these findings, this study hypothesizes that business scale positively affects firm valuation.

H3: Business scale positively affects company valuation.

2.2.4 The Role of Business Scale Moderation in the Relationship Between Environmental Costs and Firm Valuation

From the perspective of Signaling Theory, the effectiveness of a signal is influenced not only by the information conveyed but also by the characteristics of the company as the sender. Larger companies generally have more adequate resources, control systems, and financing capabilities. Hence, the implementation of environmental programs is likely to be perceived as more credible than that of smaller companies. Carandang & Ferrer (2020) show that firm characteristics influence the effectiveness of environmental practices in improving firm performance. Additionally, Veradine & Praptoyo (2024) explain that firm size can strengthen the relationship between sustainability practices and firm performance. Based on these findings, this study hypothesizes that firm size amplifies the positive effect of environmental costs on firm valuation.

H4: Business Scale reinforces the positive effect of Environmental Costs on Firm Valuation.

2.2.5 The Moderating Role of Firm Size in the Relationship Between Environmental Performance and Firm Valuation

Legitimacy Theory explains that companies with greater operational impacts face higher demands for social legitimacy. Therefore, companies with larger operations tend to have stronger incentives to demonstrate good environmental performance as part of their efforts to maintain legitimacy. From the perspective of Signaling Theory, environmental performance achievements at large-scale companies also have the potential to serve as more credible information because they are supported by greater organizational capacity to implement sustainability practices. Ifada *et al.*, (2021) show that firm size is associated with increased firm value, while Mardiana & Wuryani (2019) found that environmental performance has a positive effect on firm value. Based on this theoretical framework and the

forementioned research findings, this study hypothesizes that firm size amplifies the positive effect of environmental performance on firm valuation.

H5: *Business Scale Reinforces the Positive Impact of Environmental Performance on Firm Valuation.*

3. Research Method

3.1 Research Design

This study employs a quantitative approach with a causal-associative research design to analyze the effects of environmental costs and environmental performance on firm valuation, with firm size serving as a moderating variable. The quantitative approach was chosen because it enables objective testing of relationships between variables through statistical analysis of secondary data. The research data consist of panel data obtained from annual reports, sustainability reports, reports on the results of the Corporate Environmental Performance Rating Program (PROPER) published by the Ministry of Environment and Forestry (KLHK), and corporate financial statements published through the Indonesia Stock Exchange (IDX) during the observation period of 2021–2024.

The study population consists of all companies in the energy and raw materials sectors listed on the Indonesia Stock Exchange (BEI) during the 2021–2024 period, totaling 204 companies. The sample was selected using purposive sampling because not all companies in the population possessed characteristics aligned with the research objectives. This technique was chosen to ensure that the sample would represent companies with complete environmental and financial information, thereby enabling consistent analysis.

The sample selection criteria included:

- Companies are classified in the coal subindustry or the metals, minerals, and other subindustry based on the Indonesia Stock Exchange's classification.
- The company consistently publishes comprehensive and accessible annual reports and/or sustainability reports throughout the study period.
- The company has consistently received a PROPER rating from the Ministry of Environment and Forestry during the observation period.
- The company has all the data necessary to measure all the research variables.

The purpose of using these criteria is to obtain a sample with homogeneous characteristics and to ensure that all research variables can be measured consistently across each observation period. All data used are secondary data collected through documentation, including company reports and official government publications.

3.2 Operationalization of Variables

3.2.1 Company Valuation

Firm valuation is a dependent variable that reflects the market's assessment of a firm's value. In this study, firm valuation is proxied using the Tobin's Q ratio because it captures market expectations regarding a firm's ability to create value in the future. Tobin's Q is widely used in research on firm value because it combines market and accounting information, making it more comprehensive than indicators based solely on financial statements. This measure is based on Hidayat *et al.*, (2023), Wahidahwati &

Ardini (2021), Nuzula (2021), Heryanti and Harahap (2025), Mardiana & Wuryani (2019), and Altarawneh *et al.*, (2025).

$$\text{Tobin's Q} = \frac{\text{Market Value of Equity} + \text{Total Liabilities}}{\text{Total Assets}}$$

3.2.2 Environmental Costs

Environmental costs are all of a company's expenditures related to the prevention, control, remediation, and management of environmental impacts arising from its operations. This variable is measured by the Environmental Cost Ratio (ECR), defined as the ratio of total environmental costs to total sales. Using the ratio relative to sales aims to normalize the magnitude of environmental costs so that they can be more easily compared across companies with different scales of operation and to reduce potential distortions caused by fluctuations in net income, which are common in the mining industry. This approach is based on Khan and Gupta (2024), Veradine *et al.*, (2024), Heryanti & Harahap (2025), Hidayat *et al.*, (2023), and Saputra (2020).

$$ECR = \frac{\text{Total Environmental Cost}}{\text{Total Sales}}$$

Environmental cost data were obtained by identifying and extracting information from annual and sustainability reports, specifically from sections covering reclamation costs, environmental rehabilitation, waste management, environmental conservation, and other expenditures explicitly classified by the company as environmental costs.

3.2.3 Environmental Performance

Environmental performance refers to a company's level of success in managing its environmental impact, as assessed by an external government evaluation. This variable is proxied using the PROPER score published by the Ministry of Environment and Forestry (KLHK). PROPER ratings are converted into numerical scores: Gold = 5, Green = 4, Blue = 3, Red = 2, and Black = 1. PROPER was chosen because it is an official government indicator that objectively and consistently assesses companies' compliance with environmental management standards. This measurement approach is based on Heryanti & Harahap (2025) and Hidayat *et al.*, (2023).

$$PROPER = \frac{\text{Total PROPER Points}}{\text{Maximum Score}}$$

3.2.4 Business Scale

Business scale is a moderating variable that reflects a company's resource capacity relative to the size of its assets. This variable is proxied using the natural logarithm of total assets (Ln Total Assets), as a logarithmic transformation reduces excessive data dispersion, improves variance stability, and facilitates the interpretation of relationships between variables in regression analysis. The use of this proxy is based on Veradine *et al.*, (2024), Ifada *et al.*, (2021), and Wahidahwati & Ardini (2021).

$$\text{Firm Size} = \ln(\text{Total Assets})$$

3.3 Data Analysis Techniques

Data analysis was conducted using panel data regression to test the effects of environmental costs and environmental performance on firm valuation, as well as the moderating role of firm size. The panel regression model was selected through model specification testing to obtain the estimation model that best fits the characteristics of the research data. To test the moderating effect, the Moderated Regression Analysis (MRA) approach was used by creating interaction terms between environmental costs and firm size, as well as between environmental performance and firm size. In addition, parameter estimation was performed using White Cross-section Robust Standard Errors to obtain coefficient estimates that are more robust to potential heteroscedasticity in the panel data. The entire data processing and analysis process was conducted using statistical software suitable for panel data regression analysis.

4. Results and Discussion

4.1 Analysis Results

4.1.1 Descriptive Analysis

The research subjects consisted of companies in the energy and raw materials sectors that met the criteria for purposive sampling during the 2021–2024 period. The analysis was conducted using secondary data obtained from annual reports, sustainability reports, financial statements, and documents from the Corporate Environmental Performance Rating Program (PROPER) published by the Ministry of Environment and Forestry (KLHK). Descriptive statistics were used to provide an overview of the characteristics of each research variable prior to conducting panel data regression analysis.

Table 1. Descriptive Statistics

Variable	N	Minimum	Maximum	Mean	Std. Deviation
Company Valuation	31	0.7471	2.1565	1.3706	0.3822
Environmental Costs	31	0.0010	0.0547	0.0136	0.0175
Environmental Performance	31	0.4000	1.0000	0.7224	0.1852
Business Scale	31	27.6390	32.7557	30.3227	1.5631

Based on Table 1, the average company valuation of 1.3706 indicates that, in general, companies' market values exceed their book values. The environmental cost variable has an average of 0.0136 and relatively high variation, indicating differences in the intensity of environmental expenditures among companies. Environmental performance averages 0.7224, indicating that most companies received environmental ratings in the "relatively good" category. Meanwhile, business scale averages 30.3227, with a fairly wide range, reflecting variations in company size within the study sample.

Important note: The editor has requested that the researcher not interpret PROPER scores as "exceeding regulatory standards" without additional evidence. Therefore, the narrative merely describes the characteristics of the data without drawing normative conclusions.

4.1.2 Panel Data Regression Model Selection

The regression model was determined by testing the model specifications using the Chow Test, the Hausman Test, and the Lagrange Multiplier Test. These tests aimed to identify the panel model that best

fit the characteristics of the research data before conducting hypothesis testing. The results of the Chow Test showed a p-value of 0.0167 (<0.05), indicating that the Fixed Effects model is more appropriate than the Common Effects model. Furthermore, the Hausman Test yielded a p-value of 0.0285 (<0.05), indicating that the Fixed Effects model is more appropriate than the Random Effects model. As supporting evidence, the Lagrange Multiplier Test yielded a p-value of 0.0045 (<0.05), indicating that the panel model is preferable to the Common Effects model. Based on this series of tests, the subsequent analysis uses the Fixed Effects Model (FEM).

To improve the reliability of the coefficient estimates, the model was estimated using White Cross-section Robust Standard Errors. This approach is used to produce standard errors that are more robust to potential heteroscedasticity in panel data. Editor's corrections: The phrases "FEM definitively," "absolutely," "weakest model," and "White Cross-section Robust Standard Errors address autocorrelation" were removed because they do not conform to econometric terminology.

4.1.3 Model Validation

Table 2. Results of the F-Test

Statistics	Value
F-statistic	3.575741
Prob(F-statistic)	0.007437

The F-test result shows a p-value of 0.0074 (<0.05). This result indicates that the regression model is statistically significant overall, meaning that the independent variables, when considered together, have a significant relationship with the dependent variable in the research model.

4.1.4. Coefficient of Determination

Tabel 3. Coefficient of Determination

Statistics	Value
R-squared	0.704477
Adjusted R-squared	0.507461

The Adjusted R-squared value of 0.5075 indicates that approximately 50.75% of the variation in corporate valuation is explained by environmental costs, environmental performance, business scale, and the interaction terms in the model. Meanwhile, the remainder is influenced by other factors outside the research model that were not analyzed in this study.

4.1.5 Hypothesis Testing Results

Hypothesis testing was conducted using the regression coefficients and p-values for each variable. Hypothesis interpretation is based on a 5% significance level; thus, a variable is considered significant if its probability value is less than 0.05. In addition to examining the direct effects of environmental costs, environmental performance, and firm size on firm valuation, this study also tests the moderating effect of firm size by creating interaction terms between environmental costs and firm size, as well as between environmental performance and firm size.

To reduce the potential for multicollinearity—which commonly arises when creating interaction terms—this study applied mean centering before forming the moderating variables. This approach aims to improve the stability of coefficient estimates without altering the relationships among variables in the regression model.

Tabel 4. Hasil Uji t

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Constant	1.349.425	0.103064	1.309.304	0.0010
Environmental Costs	-29,25025	8.805511	-3.321812	0.0450
Environmental Performance	-0.899581	0.406905	-2.210791	0.1140
Business Scale	-0.880257	0.237102	-3.712565	0.0340
Environmental Costs × Scale of Operations	4.911454	3.758988	1.306590	0.2825
Environmental Performance × Business Scale	0.160861	0.436121	0.368844	0.7367

The MRA regression equation is as follows:

$$VP_{it} = 1.3494 - 29.2502BL_{it} - 0.8995KL_{it} - 0.8802SU_{it} + 4.9114(BL \times SU)_{it} + 0.1608(KL \times SU)_{it} + \varepsilon_{it}$$

4.2 Discussion

4.2.1 The Impact of Environmental Costs on Corporate Valuation

The test results show that environmental costs have a significant negative effect on firm valuation, so the first hypothesis is not supported. These findings indicate that an increase in the share of environmental costs borne by mining firms during the observation period was followed by a decline in firm valuation. Empirically, these results indicate that environmental expenditures are not yet fully correlated with short-term increases in firm value. From the perspective of Signaling Theory, information regarding environmental costs is expected to serve as a positive signal of a firm's commitment to sustainability. However, the results of this study show that the disclosure of information about environmental costs alone is insufficient to generate a market response consistent with theoretical expectations. In other words, the effectiveness of environmental costs as a signal is likely influenced by other factors, such as the quality of environmental program implementation, the effectiveness of disclosure, and industry characteristics associated with relatively high operational risk.

These findings align with those of Dinniyah and Nuzula (2021) and Hidayat *et al.*, (2023), who also found a negative relationship between environmental costs and firm value. Conversely, the results of this study differ from those of Heryanti and Harahap (2025), who reported that environmental costs have a positive effect on firm value, and also differ from those of Khairunisa and Pohan (2022), Saifuddin and Wiyono (2023), and Saputra (2020), who found no significant effect. These differing results indicate that the relationship between environmental costs and firm valuation still depends on firm characteristics, industry sector, and the study period's context. Therefore, the results of this study do not necessarily suggest that environmental costs reduce firm value in general; rather, they indicate that, in the sample of mining companies for the 2021–2024 period, an increase in environmental costs has not been accompanied by an increase in firm valuation.

4.2.2 The Impact of Environmental Performance on Company Valuation

The test results show that environmental performance does not significantly affect firm valuation; therefore, the second hypothesis is not supported. These findings indicate that variations in environmental performance, as measured by PROPER ratings, are not significantly related to changes in firm valuation in the study sample. From the perspective of Legitimacy Theory, companies seek to gain legitimacy by fulfilling their environmental responsibilities. In contrast, Signaling Theory explains that information regarding environmental performance can serve as a signal to external parties. However, the results of this study show that information regarding environmental performance has not had a significant relationship with firm valuation during the observation period. This suggests that environmental performance has not yet become the sole factor influencing corporate value in the mining sector.

These findings are consistent with those of Hidayat *et al.*, (2023) and Mumtazah & Purwanto (2020), who also found that environmental performance does not significantly affect corporate value. Conversely, the results of this study differ from those of Ifada *et al.*, (2021), Wahidahwati and Ardini (2021), and Mardiana & Wuryani (2019), who found a positive effect of environmental performance on firm value. These differences suggest that the effectiveness of environmental performance in enhancing firm value is likely influenced by industry characteristics, measurement indicators, observation periods, and the economic conditions underlying the studies. Therefore, the results of this study indicate that, for Indonesian mining companies during the 2021–2024 period, environmental performance, as represented by the PROPER rating, has not shown a significant relationship with firm valuation.

4.2.3 The Effect of Business Scale on Company Valuation

The test results show that firm size has a significant negative effect on firm valuation; therefore, the third hypothesis is not supported. These findings indicate that an increase in firm size—proxied by the natural logarithm of total assets—is associated with a decline in firm valuation among mining companies in the sample during the 2021–2024 period. From the perspective of Stakeholder Theory, companies with greater resource capacity are expected to be better able to meet stakeholder expectations and manage operational risks. However, the results of this study show that firm size does not always correlate positively with firm valuation. This suggests that the size of a firm's assets does not necessarily lead to increased market appreciation if the firm is unable to generate commensurate economic value or improve resource management efficiency.

This finding aligns with Carandang & Ferrer (2020), who reported a negative relationship between firm size and firm value in certain contexts. Conversely, the results of this study differ from those of Wahidahwati & Ardini (2021) and Ifada *et al.*, (2021), who found a positive effect of firm size on firm value, and also differ from Veradine & Praptoyo (2024), who found no significant relationship. These differing results indicate that the effect of firm size on valuation is not universal but can be influenced by industry characteristics, asset structure, market conditions, and a firm's ability to manage its resources. In the mining sector, firms with larger assets also face greater operational complexity, higher investment requirements, and greater exposure to environmental risks, making the relationship between firm size and valuation more dynamic than in other sectors.

4.2.4 The Role of Business Scale Moderation in the Relationship Between Environmental Costs and Firm Valuation

The test results show that the interaction between environmental costs and firm size does not significantly affect firm valuation; thus, the fourth hypothesis is not supported. This finding indicates that firm size did not strengthen or weaken the relationship between environmental costs and firm valuation in mining companies during the study period. Thus, the effect of environmental costs on firm valuation tends not to differ significantly between companies with larger and smaller asset sizes. From the perspective of Signaling Theory, these results suggest that a firm's capacity—as represented by asset size—has not consistently enhanced the effectiveness of environmental costs as a market signal.

These findings differ from those of Carandang & Ferrer (2020), who demonstrated that firm characteristics can strengthen the relationship between sustainability practices and firm value. Conversely, the findings of this study are more consistent with those of Dinniyah and Nuzula (2021) and Khairunisa & Pohan (2022), who found that environmental expenditures do not always increase firm value. These differences suggest that sample characteristics may influence the moderating role of firm size, the approach used to measure environmental costs, or the industry context employed in the research. Therefore, the results of this study suggest that, for Indonesian mining companies during the 2021–2024 period, firm size has not been a factor that strengthens the relationship between environmental costs and firm valuation. These findings also indicate that the relationship between environmental expenditures and firm value still requires further explanation through other factors, such as the quality of environmental disclosures, profitability, and the effectiveness of sustainability strategy implementation.

4.2.5 The Moderating Role of Firm Size in the Relationship Between Environmental Performance and Firm Valuation

The test results show that the interaction between environmental performance and firm size does not significantly affect firm valuation; thus, the fifth hypothesis is not supported. These findings indicate that firm size does not strengthen the relationship between environmental performance—proxied by PROPER—and firm valuation among mining companies during the 2021–2024 period. Thus, variations in firm size do not show significant differences in the relationship between environmental performance and firm valuation. From the perspective of Legitimacy Theory, firms seek to gain legitimacy through improved environmental performance. In contrast, Signaling Theory explains that information regarding environmental performance can serve as a signal to external parties. However, the results of this study indicate that the presence of firms with larger asset sizes has not significantly strengthened the relationship between environmental performance and firm valuation. This finding suggests that the effectiveness of environmental performance in shaping firm valuation is likely influenced by factors other than firm size.

This finding aligns with Heryanti & Harahap (2025) and Hidayat *et al.*, (2023), who demonstrated that firm characteristics do not always influence the relationship between environmental performance and firm value. Conversely, the results of this study differ from those of Mardiana and Wuryani (2019), who found that companies with better environmental management tend to experience an increase in corporate value. This discrepancy in results suggests that the impact of environmental performance on corporate valuation is likely influenced by industry characteristics, measurement indicators, market

conditions, or internal company factors not analyzed in this study. Therefore, the results of this study suggest that, for Indonesian mining companies during the 2021–2024 period, firm size has not been a factor that strengthens the relationship between environmental performance and corporate valuation. This finding also opens opportunities for future research to consider other variables—such as the quality of sustainability disclosures, profitability, corporate governance, or the level of ESG implementation—as factors that may influence this relationship.

5. Concluding Remarks and Recommendation

This study aims to analyze the effects of environmental costs and environmental performance on firm valuation, with firm size as a moderating variable, among mining companies listed on the Indonesia Stock Exchange during the 2021–2024 period. The study employs a quantitative approach using panel data regression analysis to test the relationships among the variables. The results show that environmental costs and firm size have a significant negative effect on firm valuation, while environmental performance has no significant effect. Furthermore, firm size was not found to moderate the relationship between either environmental costs or environmental performance and firm valuation. These findings indicate that the relationship between environmental management practices and firm valuation in the mining sector remains complex and is not fully determined by the magnitude of environmental costs, environmental performance, or firm size.

This study contributes to the literature on the relationship between environmental factors and firm value in Indonesia's mining sector. From a theoretical perspective, the results demonstrate that the effectiveness of Signaling Theory, Legitimacy Theory, and Stakeholder Theory in explaining the formation of firm value may vary depending on industry characteristics and the research context. From a practical standpoint, the findings provide insights for corporate management regarding the importance of improving the quality of environmental information implementation and disclosure so that the economic benefits of sustainability activities can be communicated more effectively to stakeholders. For regulators, these findings highlight the importance of improving the quality and consistency of environmental reporting so that the available information becomes more comprehensive and relevant for decision-making. The novelty of this study lies in testing the moderating role of firm size in the relationships among environmental costs, environmental performance (proxied by PROPER), and firm valuation among Indonesian mining companies during the 2021–2024 period.

This study has several limitations that should be considered when interpreting the results. First, the study only included mining companies that met the sample criteria; therefore, the results cannot yet be generalized to the entire industry sector. Second, the measurement of environmental costs and environmental performance relies on information disclosed in annual reports, sustainability reports, and PROPER data; thus, it remains subject to the availability and completeness of corporate disclosures. Third, the study used only firm size as a moderating variable; therefore, it remains possible that other factors influence the relationship between environmental aspects and firm valuation. Consequently, future research is recommended to expand the observation period and the scope of industrial sectors, use a larger sample size, consider environmental cost indicators based on content analysis such as the Global Reporting Initiative (GRI) or the Sustainability Accounting Standards Board (SASB), and include other variables such as profitability, leverage, the quality of corporate governance, and ESG indicators to gain a more comprehensive understanding of the factors influencing corporate valuation.

Statement of Use of Generative AI

During the preparation of this work, the author used generative artificial intelligence tools to support the scientific writing process. Grammarly was used to check grammar, refine writing style, and improve clarity in scientific writing. All interpretations, analyses, and conclusions presented in this study are the sole responsibility of the author.

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