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Impact of Green Innovation, Accounting, and Eco-Efficiency on Environmental and Corporate Performance

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Abstract

Purpose: This study aims to examine the effect of green innovation, green accounting, and eco-efficiency on environmental performance, and analyze its impact on company performance.

Methodology: This research uses quantitative methods with descriptive and verification approaches. The data used comes from the financial statements of mining companies listed on the Indonesia Stock Exchange (IDX) in the 2019-2023 period. The analysis techniques used include multiple linear regression analysis and hypothesis testing with SPSS as a tool.

Results: The results of the study, it was found that green innovation and green accounting have a significant positive effect on environmental performance. In contrast, eco-efficiency shows a significant negative effect on environmental performance. In addition, environmental performance is also shown to have a significant positive impact on firm performance.

Conclusions: This study demonstrates that green innovation and green accounting have a significant positive impact on improving environmental performance. Conversely, eco-efficiency shows a significant negative effect on environmental performance. Furthermore, strong environmental performance positively and significantly contributes to enhancing corporate performance. Therefore, emphasizing green innovation and green accounting is crucial for supporting environmental sustainability while simultaneously improving corporate performance.

Limitations: This study only observes mining companies listed on the Indonesia Stock Exchange for 5 years, namely the 2019-2023 period, so this research does not represent the actual conditions of various company sectors.

Contribution: These findings support the importance of implementing environmentally friendly practices as part of a strategy to improve company performance in the mining sector.

Keywords: *Corporate Performance, Eco-Efficiency, Environmental Performance, Green Accounting, Green Innovation*

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1. Introduction

Globally, and particularly in industrialized countries, development has experienced significant growth in recent years (Hasibuan *et al*, 2023). The expansion of Indonesia's industrial sector has similarly contributed to the country's Gross Domestic Product (GDP). One of the primary sources of export revenue originates from the mining sector. Excluding tax revenues, the coal industry generated nearly IDR 100 trillion in Non-Tax State Revenue (PNBP) in 2023. According to data compiled by the Directorate General of Mineral and Coal, the mining industry employed more than 333,000 workers in 2023 and allocated approximately IDR 2.5 trillion to community empowerment programs in and around

mining areas. According to Sinaga, (2024) these figures highlight the substantial economic and social impacts of mining operations on local communities.

However, behind these contributions lie major environmental and social challenges. Other studies explain that the presence of coal mining activities in Indonesia has indeed increased local community income by creating numerous employment opportunities, both directly within the mining sector and indirectly through supporting industries (Zamroni *et al.*, 2022). Nevertheless, these activities also generate negative externalities, including air pollution, noise pollution, and respiratory health problems among surrounding communities. From a social perspective, mining activities have led to disparities between communities involved in mining and those that are not, as well as a shift from traditional collective values toward more individualistic lifestyles. Furthermore, the study The Impact of Indonesia's Mining Industry Regulation on the Protection of Indigenous Peoples emphasizes the urgent need for regulatory reform in the mining sector to comprehensively protect the rights of indigenous communities (Jamin *et al.*, 2023). The study highlights that existing regulations remain weak in implementation, exposing indigenous communities to risks of land dispossession and loss of access to natural resources.

The decline in environmental quality is inseparable from environmental incidents, such as those involving PT Indominco Mandiri and PT Medco Energi Internasional Tbk, which have been recorded as perpetrators of environmental pollution (Amelia, 2017). According to reports by the Mining Advocacy Network (JATAM), approximately 70% of environmental degradation in Indonesia is attributed to mining activities, with 3.97 million hectares of protected areas affected and 108 out of 4,000 watersheds experiencing severe damage (Sulistya, 2025). This situation indicates that poor environmental management can adversely affect corporate performance (Handoyo *et al*., 2022). Several studies have demonstrated that strong environmental performance positively influences firm performance. For instance,, Susanti *et al.*, (2023); Ramlawati *et al*., (2022); Zalukhu *et al.*, (2022) found that effective environmental management enhances investor perceptions and corporate profitability. However, other studies report that environmental performance does not significantly affect firm performance (Salsabila & Novianty, 2022).

One factor that may influence environmental performance is green innovation, defined as environmentally friendly innovation aimed at improving energy efficiency and reducing waste (Kraus *et al.,* 2020); (Nashrulloh & Achyani, 2024); (Santoso & Yanti, 2024). This approach has been implemented by MIND ID, Indonesia's state-owned mining holding company, through the BIGMIND Innovation Award, initiated in 2022. The program focuses on developing innovations to reduce carbon emissions throughout the coal value chain, from extraction to energy utilization. The competition is open to the public and aims to promote innovative approaches to carbon emission control, including carbon capture, utilization, and storage (CCUS) technologies and other efficient emission reduction methods (Aulia, 2022). Empirical studies by Ahmed *et al.*, (2023); Rehman *et al.*, (2021); Fang *et al.,* (2022); Nofita Sari *et al.*, (2024); Ramadhani Abanan & Isharina, (2024) indicate that green innovation encompassing green accounting, corporate social responsibility (CSR), and green creativity positively affects environmental performance and competitiveness. However, some studies, such as (Qiang & Yang, 2023) report insignificant effects.

In addition, green accounting plays an important role in environmental performance by enabling firms to measure, manage, and control the environmental impacts of their activities while ensuring compliance with sustainability regulations (Rahman & Islam, 2023); (Fina, 2024). Despite its importance, the adoption of green accounting practices in Indonesia remains relatively low (Pramudita & Gunawan, 2023). Several studies report a significant influence of green accounting on environmental performance (Purwaatmojo & Ratmono, 2024); (Ulupui et al., 2020); (Ratmono et al., 2023), although other studies have produced contrasting findings (Dwipa et al., 2021). Another relevant factor is eco-efficiency, which represents a strategy that integrates economic and ecological efficiency through the optimal use of natural resources (Saputra *et al.*, 2022). Eco-efficiency is considered capable of improving environmental performance while simultaneously reducing production costs. Empirical evidence from Putri & Sari, (2019); Sunarjo *et al.,* (2024); Dewi & Rahmianingsih, (2020); Khairunissa

& Santosa, (2022) support this view that the implementation of eco-efficiency is able to improve environmental performance and reduce production costs; however Lukia & Lestari, (2024) argue that the impact of eco-efficiency on environmental performance may vary depending on contextual factors.

This study is particularly important due to inconsistencies in prior empirical findings and the limited number of studies examining environmental performance in Indonesia's mining industry, especially among companies listed on the Indonesia Stock Exchange (IDX). Therefore, this research focuses on analyzing the effects of green innovation, green accounting, and eco-efficiency on environmental performance, as well as their subsequent impact on firm performance, drawing on previous studies such as (Susanti *et al.,* 2023*)*; (Ahmed *et al.,* 2023); (Saputra *et al.,* 2022). In addition, this study refers to recent findings from Indonesia's mining sector, including:

1. Riadi & Aqshal, (2023) who found that green accounting disclosure measured through environmental cost disclosure and GRI and PROPER indicators significantly affects the financial performance of mining companies included in the index.
2. Nurrasyidin *et al.,* (2024) who reported that the implementation of green accounting and CSR in Indonesian mining companies from 2012–2021 does not have a significant partial effect on profitability, although both practices remain important simultaneously from a social legitimacy perspective.
3. Fitrifatun & Meirini, (2023) who found that green accounting implementation, environmental performance, firm size, and liquidity influence the profitability of IDX-listed mining companies during 2018–2022; notably, green accounting showed a negative partial effect, while environmental performance, firm size, and liquidity had positive effects.
4. Okterianda et al., (2025) who revealed that green accounting practices have a negative partial relationship with profitability, but when combined with environmental performance as measured by PROPER, both variables simultaneously influence profitability.

These four studies reinforce the importance of examining the role of green accounting in Indonesia's mining industry, both directly and through its interaction with environmental performance.Based on existing empirical evidence and prior studies highlighting the influence of various factors on environmental performance, this study seeks to further investigate the role of these factors in enhancing corporate performance. Accordingly, this research aims to examine the effects of green innovation, green accounting, and eco-efficiency on environmental performance, as well as their implications for firm performance among mining companies listed on the Indonesia Stock Exchange during the 2019–2023 period.

2. Literature Review and Hypothesis Development

2.1. Green Innovation

When an organization achieves its environmental objectives and implements new innovations that contribute to environmental protection, such initiatives are referred to as green innovation (Pramudita & Gunawan, 2023). In this study, green innovation is measured using a dummy variable that captures whether an organization has obtained ISO 14001 certification. Green innovation is operationalized based on the organization's commitment to an environmental management system. An organization is assigned a value of 1 if it has obtained ISO 14001 certification, indicating a strong commitment to environmentally friendly operations. Conversely, companies without this certification are assigned a value of 0, reflecting the absence of a formally recognized environmental management system (Cahyaningtyas et al., 2022). The measurement formula is presented as follows:

Table 1. Green Innovation

1	The company has obtained ISO 14001 certification
0	The company has not obtained ISO 14001 certification

Source: (Cahyaningtyas *et al.,* 2022)

2.2. Green Accounting

According to the Environmental Protection Agency (EPA), green accounting refers to the practice of identifying, prioritizing, measuring or quantifying environmental costs and incorporating them into

business decision-making processes (Sari & Rakhmawati, 2023). Companies are considered to be more concerned with social and environmental sustainability when their green accounting ratio is high, as this indicates a stronger commitment to allocating income toward environmentally oriented initiatives. In this study, green accounting is measured using corporate social responsibility (CSR) expenditure as a percentage of net profit after tax, following the approach proposed by (Haryono et al., 2010).
The formula used is as follows:

$$Green\ Accounting = \frac{CSR}{Net\ Profit\ After\ Tax}$$

2.3. Eco-Efficiency

Eco-efficiency refers to the ability to maximize a company's operational performance while simultaneously reducing its environmental impact (Meutia et al., 2019). A lower level of eco-efficiency is preferable, as it indicates that the company generates fewer carbon emissions per unit of sales, thereby minimizing negative environmental impacts. In this study, eco-efficiency is measured using the ratio between the total amount of carbon dioxide (CO_2) emissions including emissions related to energy, water, and waste activities expressed in metric tons, and the company's total sales, measured in million rupiah (Lorenza & Sudrajat, 2024). The formula used is as follows:

$$Eco - efficiency = \frac{Matrix\ Ton\ CO2}{Total\ Sales\ (millions\ of\ rupiah)}$$

2.4. Environmental Performance

The environmental performance variable serves as a mediating variable within the research framework. Wang *et al.,* (2021) state that one way to assess environmental performance is by evaluating the extent to which a company's activities affect the environment. In Indonesia, companies can utilize the PROPER rating system, developed by the Ministry of Environment and Forestry (KLHK), to measure the effectiveness of their environmental management practices.

PROPER is a monitoring and evaluation tool used to assess corporate environmental management performance. Companies with low compliance in environmental management receive a Black rating, which reflects the lowest level of environmental performance and is assigned a value of 1. Conversely, a Gold rating represents excellent environmental management performance and is assigned a value of 5 (Ulupui et al., 2020). This assessment is conducted based on predefined criteria, and each rating is assigned a numerical value as follows:

Table 2. Environmental Performance Assessment

Rating	**Poin**
Black	1
Red	2
Blue	3
Green	4
Gold	5

Sumber: (Ulupui *et al.,* 2020)

2.5. Firm Performance

Firm performance reflects the extent to which a company is able to achieve its strategic objectives through the effective and efficient management of its resources. It represents how well a business utilizes its resources to accomplish its long-term goals. For the purposes of this analysis, Return on Equity (ROE) is used as the primary indicator of firm performance. ROE measures a company's ability to convert shareholders' equity into net income. A higher ROE indicates superior business performance, as it reflects management's capacity to generate higher profits from shareholders' invested capital. Return on Equity (ROE) is widely recognized as a key metric for evaluating management effectiveness in generating profits from shareholders' funds (Kasmir, 2017).

$$Return\ on\ Equity = \frac{Net\ profit}{Total\ Equity}$$

2.6. The Effect of Green Innovation on Environmental Performance

The concept of green innovation refers to a strategic approach adopted by businesses to develop products, processes, or business practices that are less harmful to the environment. The primary objective of green innovation is to minimize the negative environmental impacts of corporate activities, including but not limited to pollution, carbon emissions, and the excessive extraction of natural resources. Green innovation encompasses the adoption of low-emission technologies, the use of environmentally friendly raw materials, improvements in energy efficiency, and the implementation of recycling initiatives. Within the sustainability framework, the goal of green innovation extends beyond regulatory compliance to enhancing an organization's overall environmental performance. Improvements in environmental performance can be reflected through reductions in greenhouse gas emissions, more effective waste management, increased efficiency in water and energy use, and an overall reduction in carbon footprint.

Batool et al., (2025) in their study Green Innovation and Environmental Performance: The Moderating Roles of Governance and Policy published in World, employed difference-in-differences, propensity score matching (PSM), and generalized method of moments (GMM) analyses using data from Chinese firms between 2017 and 2022. Their findings indicate that green innovation significantly improves corporate environmental performance, and this positive effect is further strengthened by strong corporate governance practices and stringent environmental policy pressures.

M. Liu et al., (2024) in The Impact of Green Innovation on Corporate Performance: An Analysis Based on Substantive and Strategic Green Innovations published in Sustainability, report that both substantive and strategic green innovations contribute positively to environmental performance. However, the study also notes that strategic green innovation may exert a negative effect on financial performance, despite its effectiveness in reducing CO_2 emissions per unit of assets.

Furthermore Palupi & Nariman, (2025) find that in Indonesia's strategic sectors, green investment positively affects financial performance, whereas carbon emission disclosure and leverage have negative effects. Collectively, these studies demonstrate a consistent pattern indicating that green innovation directly supports improvements in corporate environmental performance, although its effectiveness may be influenced by internal governance structures and the type of green innovation implemented.

Prior empirical research also generally supports the positive impact of green innovation on environmental and corporate performance. Studies by Kraus *et al*., (2020); Ahmed *et al.,* (2023); Rehman *et al.*, (2021); Wang *et al.,* (2021); Fang *et al.,* (2022), document that green innovation reduces negative environmental impacts while enhancing firms' economic and social performance. Nevertheless, contrasting evidence is reported by Qiang & Yang, (2023), who conclude that the relationship between green innovation and environmental performance is weak or statistically insignificant. Based on the theoretical framework and empirical findings discussed above, the following hypothesis is proposed:

H1: Green Innovation has an effect on Environmental Performance.

2.7. The Effect of Eco-Efficiency on Environmental Performance

Eco-efficiency is a theoretical framework that encourages businesses to maximize resource utilization in an efficient and sustainable manner, with the objective of minimizing negative environmental impacts while maintaining or improving economic performance. By adopting eco-efficiency practices, firms seek to conserve energy, reduce waste, and minimize emissions, all of which directly contribute to improvements in environmental performance. These practices not only help companies lower operational costs but also enhance corporate reputation and image in the eyes of stakeholders.

Consequently, firms that adopt eco-efficiency approaches in their operations tend to achieve superior environmental performance, generating positive economic and ecological outcomes.

Previous studies on eco-efficiency have been widely conducted. For instance, (Yuliandhari et al., 2023) found that the implementation of eco-efficiency integrated with green innovation enhances firm value, which indirectly supports environmental performance through an increasingly positive corporate reputation. This finding suggests that eco-efficiency strategies significantly reduce carbon emission intensity per unit of output, thereby directly improving environmental performance and supporting the achievement of the Sustainable Development Goals (SDGs), particularly Goal 12: Responsible Consumption and Production.(He & Reith, 2022) Similarly, the study Data-Driven Eco-Efficiency Evaluation and Optimization in Industrial Production by C. Liu et al., (2021) published in *Energy*, demonstrates that data-driven approaches can significantly evaluate and optimize eco-efficiency in manufacturing processes, enabling more effective control of energy use and emissions. Furthermore, prior empirical studies generally indicate that eco-efficiency improves environmental performance. Research Saputra *et al.,* (2022); Putri & Sari, (2019); Sunarjo *et al.,* (2024) suggests that eco-efficiency encourages firms to balance environmental and economic performance. Khairunissa & Santosa, (2022) further argue that environmentally conscious initiatives, such as cost reduction and sustainable supply chain management, positively affect environmental outcomes. However, Lukia & Lestari, (2024) note that the impact of eco-efficiency on environmental performance is not always consistent, as performance outcomes may vary depending on the duration of environmental certification. Based on the theoretical arguments and empirical evidence above, the following hypothesis is proposed:
H3: Eco-efficiency has an effect on Environmental Performance.

2.8. The Effect of Environmental Performance on Firm Performance

Environmental performance refers to a firm's capacity to manage resource consumption, waste generation, and carbon emissions effectively. It plays a crucial role in shaping corporate image and influencing investor perceptions. In many cases, firms with strong environmental performance experience higher net profits. Government recognition of environmental performance can further enhance financial outcomes by improving investor and customer confidence. Companies that demonstrate strong environmental responsibility and actively pursue environmental improvements tend to achieve superior overall performance.

Previous research consistently indicates that higher environmental performance leads to more positive organizational outcomes. Studies by Susanti *et al.,* (2023); Ramlawati Ramlawati *et al.,* (2022) show that positive perceptions of corporate environmental management practices among customers and investors enhance profitability and overall firm performance. Investors tend to view firms with strong environmental performance more favorably, which contributes to higher long-term revenues (Anwar & Abdullah, 2021). Conversely, Salsabila & Novianty, (2022) report contradictory findings, concluding that environmental performance does not significantly affect firm performance.

Research in the field of environmental accounting also highlights the importance of environmental performance disclosure and corporate governance in increasing firm value. Fasya et al., (2024) found that carbon emission disclosure and institutional ownership positively influence firm value, while the presence of independent commissioners does not significantly affect firm value in Indonesia's transportation and logistics sector. Similar findings were reported by Kodriyah et al., (2023) who demonstrated that environmental performance enhances firm value, whereas accounting conservatism does not significantly affect manufacturing firms listed on the Indonesia Stock Exchange. These studies emphasize that corporate focus on environmental management and carbon transparency is a key determinant of improved reputation and firm valuation among investors.

Alyahya & Agag, (2025) further found that a one-unit increase in corporate environmental performance leads to a 10.1% increase in ROA, a 13.4% increase in Tobin's Q, and a 14.2% increase in customer satisfaction among S&P 500 companies in the United States. Manrique & Martí-Ballester, (2017) similarly reported that strong environmental practices significantly enhance financial performance, with more pronounced effects observed in firms operating in developing countries such as Indonesia.

Additionally, Effendi, (2017) found that environmental disclosure and environmental performance positively affect the financial performance of mining companies in Indonesia. Meanwhile, Hanjani & Kusumadewi, (2023) showed that ISO 14001 implementation, audit quality, and firm characteristics significantly improve environmental performance and subsequently have a positive impact on the financial performance of Indonesian firms. Based on the above discussion, the following hypothesis is proposed:

H4: Environmental Performance has an effect on Firm Performance.

3. Research Methodology

This study employs a quantitative research approach using descriptive and verificative methods. The descriptive approach is used to identify and describe the value of each variable independently, while the verificative approach is applied to examine the extent to which Green Innovation, Green Accounting, and Eco-Efficiency affect Environmental Performance and its subsequent impact on Firm Performance.

Data processing is conducted through financial statement analysis, followed by statistical testing using SPSS version 26. Variable measurement is carried out using operational scales and ratio measurements appropriate for the objectives of this study. This research utilizes secondary data, as defined by (Sugiyono, 2019). The secondary data are obtained from the financial statements of mining companies listed on the Indonesia Stock Exchange (IDX) during the 2019–2023 period. The variables examined in this study include Green Innovation, Green Accounting, Eco-Efficiency, Environmental Performance, and Firm Performance.

The data analysis procedures consist of descriptive statistics, classical assumption tests, multiple linear regression analysis, and hypothesis testing. Descriptive statistics are used to describe data characteristics based on the mean, median, minimum, maximum, and standard deviation of each variable. Classical assumption tests are conducted to evaluate the feasibility of the regression model prior to further analysis and to ensure that the estimation results satisfy the BLUE (Best Linear Unbiased Estimator) principle. The classical assumption tests applied in this study are as follows:

3.1. Normality Test

The normality test is conducted based on the following assumptions to determine whether the research data are normally distributed:

1. The data are considered normally distributed if the significance value of the Kolmogorov–Smirnov test on the residuals of the multiple linear regression exceeds 0.05.
2. The data are considered not normally distributed if the Kolmogorov–Smirnov test results for the regression residuals show a significance value below 0.05.

3.2. Multicollinearity Test

This test is conducted based on the following assumptions to determine whether multicollinearity exists:

1. Multicollinearity is indicated if the Variance Inflation Factor (VIF) value exceeds 10.
2. No multicollinearity is indicated if the VIF value is below 10.

3.3. Heteroskedasticity Test

The heteroskedasticity test aims to identify whether there is inequality in the variance of residuals across observations in the regression model. A significance value greater than 0.05 indicates that the regression model does not exhibit heteroskedasticity. The Glejser test is employed by regressing the independent variables on the absolute value of the residuals (ABS_RES). To confirm that the data are free from heteroskedasticity, the significance value of the regression between the independent variables and the absolute residuals must exceed 0.05 (5%).

3.4. Multiple Linear Regression Analysis

Multiple linear regression analysis is conducted to evaluate the effect of multiple independent variables on a single dependent variable. This method is used to explore the relationships between independent and dependent variables and to assess the magnitude of the influence exerted by the independent

variables. To ensure that the regression model is free from issues related to normality, multicollinearity, and heteroskedasticity, multiple linear regression analysis is performed after completing the classical assumption tests.

This study employs two linear regression equations, as follows:

$$KL = a + GI + GA + EF + e$$
$$KP = a + KL + e$$

Where:
KL = Environmental Performance
α = Konstanta
GI = *Green Innovation*
GA = *Green Accounting*
EF = *Eco-Eficiency*
KP = Company Performance
e = Interference/error variables

3.5. Hypothesis Testing

Hypothesis testing is a statistical method used to determine whether the proposed research hypotheses are supported. Several hypothesis testing procedures are applied in this study, as described below:

3.5.1. F-Test

The F-test, also known as the simultaneous test, is used to examine whether all independent variables collectively have a significant effect on the dependent variable.
In the regression model:

1. The null hypothesis (H_0) states that there is no significant difference among groups or that none of the independent variables significantly influence the dependent variable.
2. The alternative hypothesis (H_a) states that there is a significant difference among groups or that at least one independent variable significantly influences the dependent variable.

3.5.2. Coefficient of Determination Test

The coefficient of determination (R^2) measures the extent to which the regression model explains the variation in the dependent variable. The value of R^2 ranges between 0 and 1. A lower R^2 value indicates that the independent variables explain only a small portion of the variation in the dependent variable. Given that this study involves multiple independent variables, R^2 provides an indication of the relative explanatory power of the model. The coefficient of determination reflects how accurately the regression model explains the dependent variable.

3.5.3. t-Test

1. The t-test is a statistical tool used to test hypotheses under the assumption that two random sample means from the same population do not differ significantly. The hypotheses are defined as follows:
2. The null hypothesis (H_0) states that the regression coefficient is equal to zero, indicating no statistically significant difference between the group means.
3. The alternative hypothesis (H_a) states that the regression coefficient is not equal to zero, indicating a statistically significant difference between the group means.

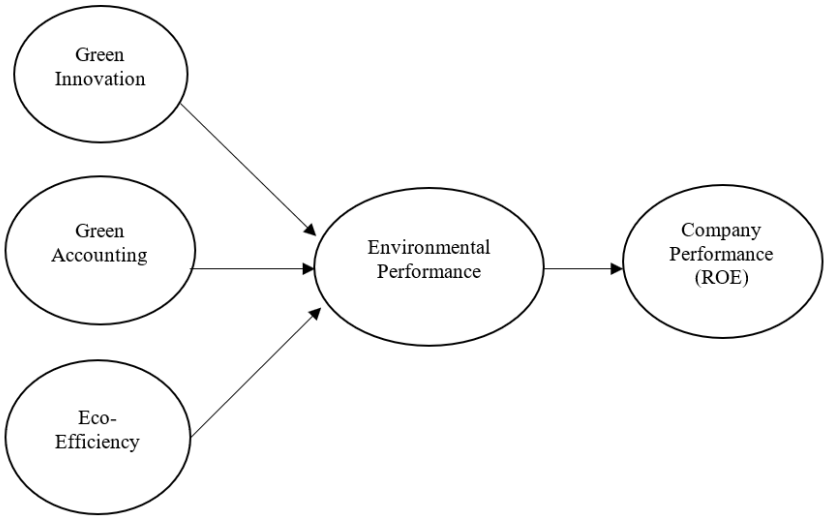

Figure 1. Research Framework
Source: (Hertati et al., 2022)

4. Result and Discussion

4.1. Result

4.1.1. Description of Research Data

Table 3. Sample Selection Results with Purposive Sampling

No	Criteria	Total
1	Mining companies listed on the Indonesia Stock Exchange (IDX) during the 2019–2023 period	63
2	Mining companies that did not publish sustainability reports or annual reports	(14)
3	Companies with incomplete data required for the research variables during the 2019–2023 period	(27)
	Research Sample	22
	Number of Research Samples (22 companies × 5 years)	110
	Outlier Data	4
	Processed Data	106

Source: Data analysis results, 2025

4.2. Descriptive Statistics Results

Table 4. Descriptive Statistics

Variabel	N	Minimum	Maximum	Mean	Std. Deviation
Green Innovation	106	0	1	0.78	0.414
Green Accounting	106	-3.61140	2.43760	0.2019575	0.70488738
Eco-Efficiency	106	0.0092	2.7719	0.394472	0.5689565
Environmental Performance	106	2	5	3.75	0.860
Company Performance	106	-0.5434	1.2466	0.208839	0.2929416
Valid N (listwise)	106				

Source: Data analysis results, 2025

This study employs a total of 106 observations, as presented in the descriptive statistics table. Based on the information provided, the following explanations are offered:

4.2.1. Green Innovation

Table 4 shows that during the period 2019–2023, a total of 106 data observation units were used in the descriptive statistical analysis of this study. Within these observations, green innovation takes a binary

value ranging from 0 to 1, based on a dummy scale. The mean value is 0.78, with a standard deviation of 0.414. This result indicates that the majority of firms in the sample have adopted green innovation practices, as the mean value is close to the maximum value, reflecting an adoption rate of 78%. The relatively low standard deviation suggests that the implementation of green innovation among sampled companies is fairly homogeneous.

4.2.2. Green Accounting

As shown in Table 4, the descriptive statistical analysis indicates that 106 observation units from 2019 to 2023 were examined in this study. The green accounting values among these observations range from –3.611 in 2019 (recorded by PT Indika Energy Tbk [INDY]) to 2.437 in 2023. The mean value is 0.202, with a standard deviation of 0.705. These results suggest that green accounting practices are still at an early stage of implementation and have not been widely adopted by firms, as reflected by the relatively low average adoption level of 20.2%. The relatively large standard deviation indicates substantial variation in the extent to which companies implement green accounting practices, reflecting differing levels of commitment to social and environmental sustainability.

4.2.3. Eco-efficiency

Table 4 further indicates that 106 observation units were included in the descriptive statistical analysis during the 2019–2023 period. Among these observations, PT Bayan Resources Tbk (BYAN) recorded the lowest eco-efficiency value of 0.0092, while PT Krakatau Steel (Persero) Tbk (KRAS) recorded the highest value of 2.772. The mean eco-efficiency value is 0.394, with a standard deviation of 0.569. This finding implies that, on average, firms have achieved an eco-efficiency level of 39.4%, suggesting that companies still need to improve the efficient use of environmentally friendly resources to significantly reduce carbon emissions per unit of sales. Lower eco-efficiency values indicate better performance, as they reflect lower environmental impact per unit of output. The relatively high standard deviation highlights substantial differences in eco-efficiency performance across firms.

4.2.4. Environmental Performance

Based on Table 4, the descriptive statistical results show that 106 observation units were analyzed for the period 2019–2023. Environmental performance, measured using a Likert scale ranging from 1 to 5, exhibits values between 2 and 5 across the observations. The mean value is 3.750, with a standard deviation of 0.860. This indicates that, on average, firms demonstrate a high level of environmental performance, with an average score equivalent to 68.75%, which is above the midpoint of the scale. The moderate standard deviation suggests some variation in environmental performance across firms, although the differences are not extreme.

4.2.5. Firm Performance

According to Table 4, the descriptive statistical analysis shows that 106 observation units were examined between 2019 and 2023. Firm performance, measured using Return on Equity (ROE), ranges from –0.543 (observed at PT Bumi Resources Tbk [BUMI]) to 1.246 (observed at PT Golden Energy Mines Tbk [GEMS]). The mean ROE is 0.209, with a standard deviation of 0.293. These results indicate that, on average, firms exhibit relatively strong financial performance, with an average ROE of 20.9%, reflecting efficiency in generating profits for shareholders. However, the presence of negative minimum values suggests that some firms experienced poor financial performance, and the dispersion of values indicates notable disparities in performance across companies.

Table 5. Results of the Normality Test

	Unstandardized Residual
N	106
Asymp. Sig. (2-tailed)	0,070[c]

Source: Processed data, 2025

The Asymp. Sig. (2-tailed) value is 0.070, as presented in Table 5 Since this value exceeds the significance threshold of 0.05 (0.070 > 0.05), the results indicate that the data are normally distributed.

Table 6. Multicollinearity Test Results

Variable	Tolerance	VIF	Information
Green Innovation	0.960	1.042	Multicollinearity Free
Green Accounting	0.922	1.085	Multicollinearity Free
Eco-Efficiency	0.948	1.055	Multicollinearity Free

Source: Processed data, 2025

As shown in Table 6, all independent variables have Variance Inflation Factor (VIF) values below 10 and tolerance values greater than 0.10. Therefore, it can be concluded that the regression model in this study does not suffer from multicollinearity problems.

Table 7. Heteroskedasticity Test Results

Variable	*p-value*	Information
Green Innovation	0,651	Free of Heteroscedasticity
Green Accounting	0,447	Free of Heteroscedasticity
Eco-Efficiency	0,283	Free of Heteroscedasticity

Source: Processed data, 2025

From Table 7, it can be seen that the independent variable green innovation has a significance value of 0.651, the variable green accounting has a significance value of 0.447, and the variable eco-efficiency has a significance value of 0.283. These findings indicate that all variables in the Glejser test have significance values greater than 0.05. Therefore, it can be concluded that the regression model used in this study is free from heteroscedasticity and is suitable for further analysis.

Table 8. Results of the First Multiple Regression Model

		Unstandardized Coefficients	Coefficients	Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	3.290	.158		20.858	.000
	Green Innovation	.648	.175	.312	3.694	.000
	Green Accountig	.397	.105	.325	3.776	.000
	Eco-Efficiency	-.311	.128	-.206	-2.420	.017

Source: Processed data, 2025

Based on the data presented in Table 8, the following regression equation can be formulated to support the research findings:

$$\text{EP} = 3.290 + 0.648\,GI + 0.397\,GA - 0.311\,EE + \varepsilon$$

Where **EP** denotes Environmental Performance, **GI** Green Innovation, **GA** Green Accounting, **EE** Eco-efficiency, and $\varepsilon$is the error term.

The interpretation of the regression coefficients from the first multiple linear regression equation is as follows:

1. Constant = 3.290 (positive) This result indicates that when the independent variables green innovation, green accounting, and eco-efficiency are assumed to be constant, the value of the dependent variable (environmental performance) is 3.290.
2. Green Innovation (GI) has a positive regression coefficient of 0.648. This implies that environmental performance increases proportionally with higher levels of green innovation. Conversely, a decrease in green innovation is associated with a decline in environmental performance.
3. Green Accounting (GA) has a positive regression coefficient of 0.397. This indicates that environmental performance improves as the adoption of green accounting practices increases. Conversely, environmental performance tends to decline when green accounting practices are not implemented.
4. Eco-efficiency (EE) has a negative regression coefficient of –0.311. This suggests that environmental performance decreases as the eco-efficiency ratio increases. Since lower eco-

efficiency values indicate better performance (i.e., lower emissions per unit of sales), a reduction in the eco-efficiency ratio is associated with improved environmental performance.
5. With an error term of 0.158 in the first regression equation, it can be concluded that there is an unexplained variation or disturbance of 0.158 in the model.

Furthermore, the results of the multiple linear regression analysis examining the effect of environmental performance on firm performance in this study are presented as follows:

Table 9. Results of Multiple Linear Regression Analysis (Second Equation)

		Unstandardized Coefficients	Coefficients	Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
	(Constant)	-.476	.109		-4.381	.000
	Environmental Performance	.182	.028	.535	6.465	.000

Source: Processed data, 2025

Referring to Table 9, the following regression equation can be formulated to support the findings of this study:

$$\text{FP} = -0.476 + 0.182\,EP + \varepsilon$$

Where **FP** denotes Firm Performance, **EP** Environmental Performance, and εrepresents the error term. Based on the second linear regression equation, the interpretation of the regression coefficients is as follows:

1. Constant = –0.476 (negative) This result indicates that when environmental performance is assumed to be zero, firm performance is valued at –0.476. This suggests a baseline condition in which firm performance is negative in the absence of environmental performance contributions.
2. Environmental Performance (EP) has a positive regression coefficient of 0.182. This implies that firm performance increases proportionally with improvements in environmental performance. Conversely, a decline in environmental performance is associated with lower firm performance.
3. With an error term of 0.109 in the second regression equation, it can be concluded that there remains an unexplained variation or disturbance of 0.109 within the regression model.

4.3. Discussion

4.3.1. The Effect of Green Innovation on Environmental Performance

The hypothesis testing results indicate that green innovation has a significant effect on environmental performance. Green innovation represents a strategic approach adopted by companies to develop environmentally friendly products, processes, or business practices. The findings of this study are consistent with Stakeholder Theory, which emphasizes that companies must consider the interests of all stakeholders such as local communities and government authorities in conducting their business activities.

Through the implementation of green innovations, such as the development of eco-friendly products and the utilization of renewable energy sources, companies demonstrate a tangible commitment to sustainability that aligns with stakeholder expectations. The adoption of green innovation strengthens relationships with stakeholders, helps maintain a social license to operate, and reduces the potential for conflicts or protests arising from environmental degradation.

This study provides empirical evidence that environmentally oriented innovation can enhance environmental performance. Prior studies by Kraus et al. (2020), Ahmed et al. (2023), Rehman et al. (2021), Wang et al. (2021), and Fang et al. (2022) similarly report that green innovation positively influences environmental performance. Overall, the findings of this research confirm that green innovation contributes to minimizing the negative environmental impacts of corporate activities while simultaneously improving firms' social and economic performance.

4.3.2. The Effect of Green Accounting on Environmental Performance

The statistical testing of the hypothesis reveals that green accounting has a significant effect on environmental performance. Green accounting refers to the practice of identifying, measuring, and reporting environmental costs, enabling companies to integrate sustainability initiatives into their financial and managerial decision-making processes. Green accounting is sometimes also referred to as environmental accounting. From the perspective of Stakeholder Theory, green accounting serves as a form of corporate accountability to stakeholders. By transparently disclosing environmental expenditures and sustainability-related activities, companies demonstrate their commitment to environmental responsibility, thereby strengthening stakeholder trust and supporting improved environmental performance.

Green accounting practices enable companies to provide transparent information regarding the environmental impacts of their operations, which is highly valued by stakeholders such as investors, regulators, and the broader community (Janah et al., 2023). Thus, green accounting not only enhances a company's environmental performance but also strengthens stakeholder trust in the company's commitment to implementing sustainability principles (Sumiati et al., 2022).

According to this study, green accounting has a significant influence on environmental performance. This finding is consistent with previous studies that demonstrate a significant relationship between green accounting and environmental performance (Purwaatmojo & Ratmono, 2024); (Ulupui *et al.,* 2020); (Ratmono *et al.,* 2023). In an effort to increase awareness of the importance of environmental responsibility, green accounting involves the recording of financial transactions that have an impact on the environment.

4.3.3. The Effect of Eco-efficiency on Environmental Performance

The hypothesis testing results indicate that eco-efficiency has a significant effect on environmental performance. Eco-efficiency is a concept that encourages companies to optimize the use of resources in an efficient and sustainable manner, thereby reducing negative environmental impacts while maintaining or enhancing economic performance. (Zaatariyah et al., 2023). Based on Stakeholder Theory, companies are required to demonstrate that they are able to meet expectations for operational efficiency without neglecting their environmental responsibilities.

By implementing eco-efficiency principles such as reducing energy consumption, waste, and emissions, companies not only lessen their environmental burden but also enhance firm value in the eyes of stakeholders. This approach strengthens the company's image as an institution committed to social responsibility and environmental conservation, thereby meeting stakeholder expectations while simultaneously improving environmental performance (Sopiana Putri & Arry Irawan, 2024).

This study provides empirical evidence that eco-efficiency has a significant effect on environmental performance, as demonstrated by Saputra *et al.,* (2022); Lestari & Saifuddin, (2020) Sunarjo et al., (2024), which state that eco-efficiency encourages companies to balance environmental and economic performance. Khairunissa & Santosa, (2022) this includes the fact that environmentally conscious measures, such as cost reduction and supply chain management, also have a positive impact on the environment. They further add that environmentally responsible actions through cost reduction and the implementation of supply chain management also have a positive impact on the environment.

4.3.4. The Effect of Environmental Performance on Firm Performance

The hypothesis testing confirms that environmental performance influences business outcomes. Environmental performance refers to a company's capacity to manage resource utilization, waste generation, and carbon emissions. This performance is critically important because it affects corporate reputation and shapes investor perceptions. Based on Stakeholder Theory, improvements in environmental performance serve as a positive signal to all stakeholders. When companies successfully manage their environmental impacts, they gain social legitimacy, enhance their reputation, and

strengthen trust among investors, consumers, regulators, and local communities. These outcomes, in turn, contribute positively to financial performance and support the long-term sustainability of the firm.

This study provides empirical evidence of a significant relationship between environmental performance and overall firm performance.(Sumiati *et al.*, 2022); (Ramlawati Ramlawati *et al.,* 2022). They find that appreciation of effective environmental management enhances investor and customer perceptions, thereby driving profitability and overall firm performance. Lee *et al.,* (2022) also emphasize that strong environmental performance is viewed positively by investors, thereby increasing corporate profits in the long term.

5. Conclusions

5.1. Conclusion

The results of this study indicate that green innovation has a significant effect on environmental performance. The higher the level of green innovation implemented by a company, the better its environmental performance. Conversely, companies with lower levels of green innovation tend to exhibit poorer environmental performance. Green accounting is also found to have a significant influence on environmental performance. A higher level of green accounting implementation encourages improvements in environmental performance, whereas limited adoption of green accounting practices is associated with lower environmental performance.

Eco-efficiency is found to affect environmental performance; however, the direction of this effect is negative. An increase in the eco-efficiency ratio is associated with a decline in environmental performance, while lower eco-efficiency values correspond to better environmental performance. This result reflects the measurement approach used in this study, where lower eco-efficiency values indicate fewer emissions per unit of output. Furthermore, environmental performance has a significant influence on firm performance. Companies with stronger environmental performance tend to achieve higher overall firm performance, while weaker environmental performance is associated with a decline in firm performance.

5.2. Limitations and Future Research

This study focuses on mining companies listed on the Indonesia Stock Exchange (IDX) during the 2019–2023 period. Future research is encouraged to expand the research scope by considering sector classifications based on the IDX Industrial Classification (IDX-IC), enabling the findings to be more representative and applicable across various industries. In addition, extending the observation period for example, to seven years would allow future studies to better capture long-term conditions and provide more accurate and comprehensive results.

Subsequent studies are also advised to incorporate additional variables that may influence environmental performance and firm performance. This would enrich the analysis and deepen the understanding of factors contributing to sustainable environmental and corporate performance. Several limitations of this study should be acknowledged. First, the analysis is limited to mining companies listed on the IDX over a five-year period (2019–2023), which may reduce the generalizability of the findings to other industries.

Second, this study relies on data related to green innovation, green accounting, eco-efficiency, environmental performance, and firm performance obtained from annual reports and sustainability reports. Consequently, the results are highly dependent on the completeness and transparency of corporate disclosures. Third, this study does not account for external factors such as government regulations, stakeholder pressure, and global market dynamics, which may also influence environmental and firm performance. These limitations highlight opportunities for future research to incorporate relevant external variables and develop more comprehensive analytical models.

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