

Enhancing Firm Value Through Green Investment and Green Innovation: Does Firm Size Matter in Indonesia's Energy Industry?

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ABSTRACT: Increased productivity in the energy sector has led to environmental degradation, requiring companies to address these challenges through green investment and green innovation as strategies to enhance corporate value. This study investigates the impact of these green initiatives on firm value and explores how company size moderates these relationships within energy sector companies listed on the Indonesia Stock Exchange (IDX) from 2018 to 2024. The research employs quantitative techniques and a descriptive-causal analysis approach. Using purposive sampling, nine out of 91 energy firms were selected. Data from financial, sustainability, and annual reports were analyzed using panel data regression and moderated regression analysis (MRA) via EViews 13. The findings indicate that green investment negatively affects firm value, whereas green innovation has a positive impact. Both factors influence firm value simultaneously. Notably, MRA results reveal that firm size strengthens the influence of green investment on firm value but does not moderate the effect of green innovation. The novelty of this research lies in demonstrating that firm size is a key factor that strengthens the influence of green investment on firm value, suggesting that the negative impact can be mitigated by larger firms' superior resource capacity. Consequently, energy companies should prioritize green innovation and enhance the efficiency of green investments. Large companies, in particular, should leverage their superior resource capacity to enhance the effectiveness of green investment in optimizing company value. Future research is encouraged to expand the sample size and observation period and to explore additional variables beyond firm size.

Keywords: Firm Value, Green Investment, Green Innovation, Firm Size, Energy Sector, Tobin's Q.



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INTRODUCTION

Natural resource exploitation primarily aims to meet human needs, yet excessive exploitation without conservation can lead to environmental degradation, such as, pollution, global warming, and natural resources depletion (Utomo et al., 2020). Rapid economic growth intensifies these

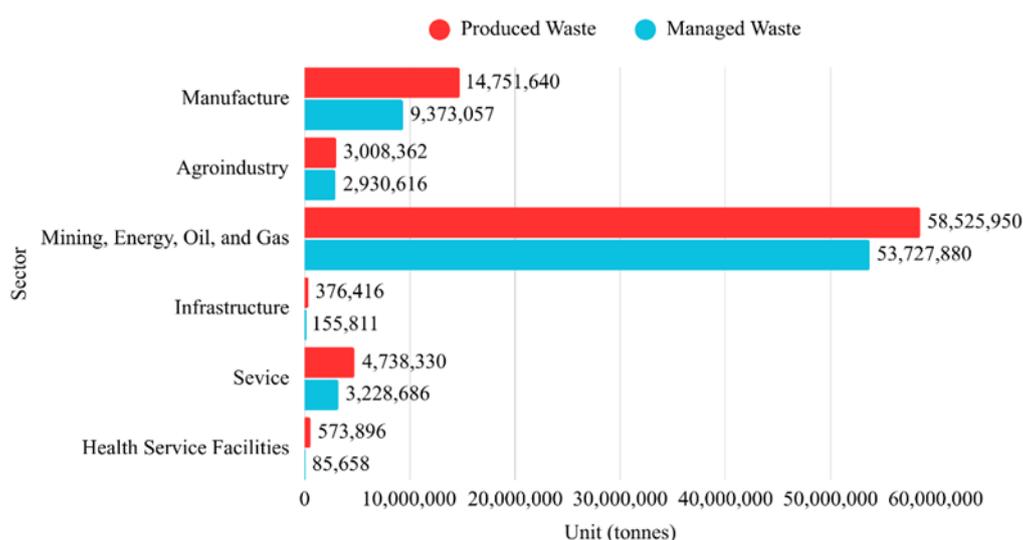
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pressures (Widyawan & Sopian, 2021). Thus, companies must now address these environmental concerns not just for compliance but also as a strategy to enhance firm value and foster sustainable development.

Consistent with this, the global energy sector has shown a trend of increasing production and consumption since the last few decades of the 1900s (Enerdata, 2025). Increased energy production has led companies in the energy sector to contribute to global warming, as the world's energy sources are still dominated by non-renewable sources, such as fossil fuels, which release greenhouse gases such as carbon dioxide (CO₂) (Yuliandhari et al., 2023). The National Oceanic and Atmospheric Administration (NOAA) reported that global surface temperatures during this decade have been the highest ever, peaking in 2024. This represents an increase of 1.47°C compared to the pre-industrial era, as reported by Lindsey & Dahlman, (2025).

Figure 1. Hazardous and Toxic Waste Management by Sector in Indonesia in 2023



Source: BPS-Statistics Indonesia, processed by author (2024)

Furthermore, environmental pollution in Indonesia is inseparably linked to the energy industry. According to Figure 1, the mining energy, oil, and gas sector was the largest producer of hazardous and toxic materials waste, accounting for 58 million tons of the total 82 million tons produced in 2023 (BPS-Statistics Indonesia, 2024). This is due to Indonesia's high energy demand in 2023, reaching 1.220 million barrels of oil equivalent (BOE) (Ministry of Energy and Mineral Resources, 2024). However, the management of hazardous and toxic waste has not been optimally implemented by the average industry, especially the energy industry. The improper disposal of hazardous and toxic waste is a significant contributor to the contamination of water, groundwater, and soil (Widyawan & Sopian, 2021).

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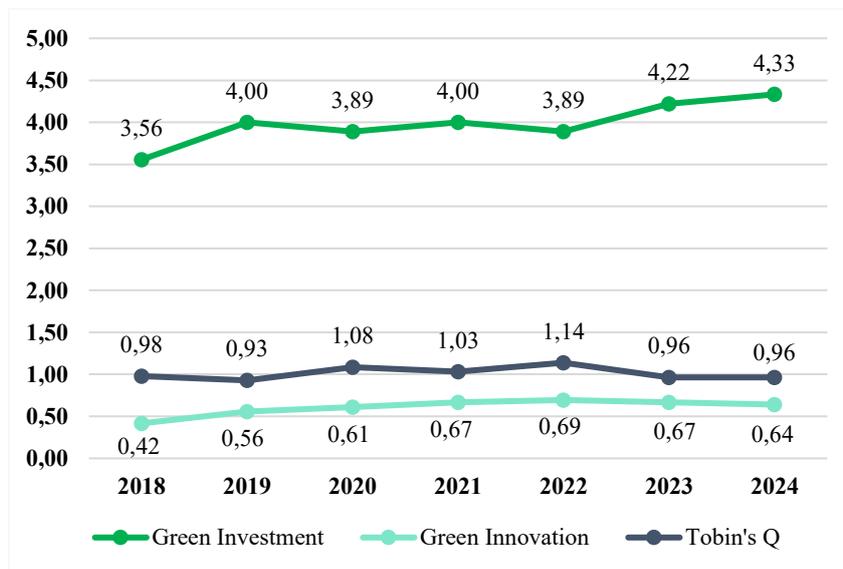
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The Indonesian government's response to sustainability issues was the issuance of POJK No. 51/OJK.03/2017, requiring public firms to implement and disclose their sustainability activities, encompassing economic, environmental, social, and corporate governance (ESG) dimensions (Wijaya & Novianto, 2024). The implementation of this regulation starting in 2018 involved significant costs that could potentially impact corporate profits. This period coincided with a notable negative market response in the energy sector, as reflected in the performance of the IDX Energy Index (IDXENERGY). Based on the IDX Index Fact Sheet IDXENERGY (2024), IDXENERGY experienced a correction of -0.4% in 2018 and a sharp decline of -17.3% in 2019 (Indonesia Stock Exchange, 2024). These trends suggest a period of adjustment in the energy sector's firm value as companies began aligning with the new sustainability disclosure requirements.

Firm value represents how much an investor views a company as worth, based on its past performance, current success, and potential for future growth, which is shown by the price of its shares (Nuur & Komara, 2024; Oktaviani & Al Ghozi, 2025; Rahelliamelinda & Handoko, 2024; Rama & Paramita, 2025; Safitri & Paramita, 2025). A firm's value can be assessed using Tobin's Q, along with other financial ratios. Tobin's Q offers a more comprehensive understanding of a company's current market value and future growth expectations by integrating both equity and debt values relative to the firm's total assets (Utomo et al., 2020; Zhang et al., 2020). Besides financial perspectives, sustainability and environmental factors can influence firm value, such as ESG disclosure, sustainability reports, green investment, green innovation, etc. (Adhia & Paramita, 2025; Paramita & Ali, 2023; Qudratulloh & Desmiza, 2024; Tiranda et al., 2025; Zhang et al., 2020).

To increase firm value, companies need to accommodate stakeholder interests through social responsibility by implementing environmental conservation efforts, namely green investment and green innovation (Utomo et al., 2020). A concrete way to implement green investment is to adhere to the PROPER assessment standards set by Indonesian Ministry of Environment and Forestry, as these standards demonstrate that a company follows environmentally friendly practices and is committed to sustainability (Ministry of Environment & Forestry, 2019). Meanwhile, green innovation emphasizes saving energy and water through technology, reducing waste through recycling, using environmentally friendly materials and packaging, and reusing components or materials in the production process (Agustia et al., 2019). These green initiatives can increase firm value by meeting stakeholder demands, gaining public legitimacy, and serving as a positive signal that can boost the firm's reputation and stock price (Laela et al., 2024). A preliminary study was carried out on a sample of energy companies on IDX that released sustainability reports and participated in PROPER between 2018 and 2024. The data is presented in Figure 2.

Figure 2 Average Movement of GIe, GIo, and Tobin's Q



Source: Processed data (2025)

According to Figure 2, there is a noticeable gap in the relation between the PROPER score and Tobin's Q from 2019 to 2023. This gap indicates that when green investment increases, firm value tends to decrease, and vice versa. Similarly, there is a gap in the relationship between Green Innovation and Tobin's Q in 2019, 2021, and 2023, suggesting a contrasting pattern. This phenomenon indicates a gap between theory and actual reality (Oktaviani & Al Ghozi, 2025). This gap prompted the authors to add a moderating variable, namely firm size. Bigger companies tend to have more resources, enabling them to carry out and manage green initiatives more effectively (Rahmawati & Sartika, 2025).

Previous studies examining how investing in green activities, such as green investment, affects a company's value have yielded inconsistent findings. Research by Putri & Paramita (2025) and Widarwati et al. (2024) suggests that green investment can improve firm value. However, a study by Pardede et al. (2024) and Maulana (2024) indicates that green investment decreases firm value because the implementation requires high costs and a relatively long payback period. In contrast, Azhari & Hasibuan (2023) and Hasanah & Paramita (2025) suggested that green investments do not significantly affect firm value in the short term.

In addition, Damas et al. (2021) and F. Zhang et al. (2020) have indicated that green innovation has a positive effect on the value of a company, which is different from the results found by Xie et al. (2022) and Yao et al. (2019), who observed a negative impact. Meanwhile, research by Rahelliamelinda & Handoko (2024) discovered that green innovation is not a key consideration for investors' decision-making, and as a result, it does not influence the value of firms.

Previous studies specifically addressing the moderating role of company size on the relationship between green investment and firm value remain limited. Rahmawati & Sartika (2025) found that this relationship was not moderated by company size. Similarly, findings regarding the moderating

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effect of company size on the green innovation-firm value relationship have been inconclusive. Some studies, such as Anggraini & Gunawan (2024), found that firm size strengthens this relationship, whereas others, such as Tonay & Murwaningsari (2022) did not.

While a study by Rahmawati & Sartika (2025) has examined these variables, this research presents a different perspective by concentrating on the Indonesian energy sector, which is under intense environmental and regulatory pressures. This study extends the observation period to 2018–2024 to better capture how the market reacts to recent sustainability regulations. Methodologically, the study employs the PROPER rating as a more objective, reliable, and standardized metric to assess green investments. Additionally, Tobin's Q is utilized as the proxy for firm value, providing a comprehensive measure that captures both the market's valuation and the replacement cost of assets. In summary, this study aims to examine whether a firm's scale moderates the impact of green initiatives on the value creation among Indonesian energy companies.

Stakeholder Theory

Stakeholder theory describes how a company works to maintain relationships with its stakeholders, namely by satisfying their demands to gain their support (Laela et al., 2024; Putri & Paramita, 2025; Sari et al., 2024; Utomo et al., 2020). Stakeholder dissatisfaction triggers opposition actions, such as demonstrations, boycotts, etc., which can damage a company's reputation and lead to a decline in firm value (Utomo et al., 2020). Therefore, good relationships with stakeholders need to be maintained to protect the company's image and maintain public trust.

Legitimacy Theory

Legitimacy theory describes how a company relates to society and seeks public legitimacy by conducting operations in accordance with prevailing values and norms (Agustia et al., 2019; Putri & Paramita, 2025; Sari et al., 2024; Widyawan & Sopian, 2021). Public legitimacy encourages companies to implement responsible and sustainable business practices to build a positive image or reputation for their activities (Widyastuti & Enderwati, 2025).

Signaling Theory

Signaling theory explains how companies attempt to send specific signals to investors about their prospects and performance to reduce information asymmetry (Brigham & Houston, 2019; Tonay & Murwaningsari, 2022; Yuliandhari et al., 2023). These signals are significant for investors because they offer valuable insights into a company's historical performance, current status, and potential future trajectories, thereby facilitating more informed decision-making (Kurnianta & Dianawati, 2020).

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Firm Value

Firm value represents how much an investor views a company as worth, based on its past performance, current success, and potential for future growth, which is shown by the price of its shares (Nuur & Komara, 2024; Oktaviani & Al Khozi, 2025; Rahelliamelinda & Handoko, 2024; Rama & Paramita, 2025; Safitri & Paramita, 2025). A firm's value can be assessed using Tobin's Q, along with other financial ratios. Tobin's Q offers a more comprehensive understanding of a company's current market value and future growth expectations by integrating both equity and debt values relative to the firm's total assets (Utomo et al., 2020; Widarwati et al., 2024; Zhang et al., 2020). A Tobin's Q value above 1 indicates that a company's market value exceeds its replacement cost due to strong growth prospects. Conversely, when Tobin's Q is less than 1, the market may be undervaluing the company, or the company's asset management may be inefficient (Tambunan, 2023). Therefore, the formula is as follows (Utomo et al., 2020):

$$\text{Tobin's Q} = \frac{\text{MVE} + \text{Book Value of Debt}}{\text{Total Asset}}$$

Green Investment

Green investment is defined as the allocation of corporate funds to initiatives aimed at reducing environmental harm, including pollution, climate change, and resource depletion resulting from business operations, with the objective of achieving sustainable development (Azhari & Hasibuan, 2023; Paramita & Ali, 2023; Rosyid & Mulatsih, 2024; Widarwati et al., 2024). The green investment indicator used in this study is the PROPER rank, that evaluates corporate performance in environmental pollution control, energy efficiency, environmental innovation, and the implementation of environmental management systems (Ministry of Environment and Forestry, 2019). The PROPER rating was chosen as a proxy because it reflects the implementation of green investment verified by official institutions (Widarwati et al., 2024). Each rating is assigned a score to convert the data to an ordinal scale, such as 5 (Gold), 4 (Green), 3 (Blue), 2 (Red), and 1 (Black) (Tanasya & Handayani, 2020; Yulianti & Ramli, 2025).

Business practices that reduce pollution, emissions, waste, and conserve energy and water consumption earn companies' stakeholder support and public legitimacy, according to stakeholder and legitimacy theory (Y. Zhang & Berhe, 2022). Stakeholder support and public legitimacy foster a company's long-term reputation, thereby increasing firm value. Research conducted by Murwaningsari & Rachmawati (2023), Sanjaya & Lestari, (2025), and Widarwati et al. (2024), demonstrates that green investment positively impacts firm value.

H1: Green Investment Positively Impacts Firm Value.

Green Innovation

Green innovation is the use of technology in production processes to minimize environmental impact and utilize resources efficiently, thereby achieving a competitive advantage (Agustia et al.,

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2019; Dai & Xue, 2022; Salihi et al., 2024; Sari et al., 2024; Zhang et al., 2020). Green innovation is measured using content analysis of corporate sustainability reports. The indicator is calculated as the ratio of the total number of items disclosed by the company to the total possible disclosure items, as outlined by Agustia et al. (2019). Each item disclosed by the company is given a score of 1, while each item not disclosed is given a score of 0 (Agustia et al., 2019):

$$Glo = \frac{\text{Total Disclosed Items}}{\text{Total Disclosure Items}} \quad (4)$$

Implementing green innovation improves a business's competitive advantage, making it uniquely attractive to investors as a potential source of long-term cash flow while mitigating negative environmental impacts and aligning with prevailing social norms and values (Damas et al., 2021; P. Sari et al., 2024; Xie et al., 2022). This is consistent with legitimacy and signaling theory, which suggests that societal legitimacy and a company's competitive advantage can act as positive signals to the market, drawing in more investors and enhancing the firm's value. Previous research by Laela et al. (2024), P. Sari et al. (2024), and F. Zhang et al. (2020), demonstrated that green innovation has a positive impact on the value a company.

H2: Green Innovation Positively Impacts Firm Value.

Firm Size

Firm size refers to a company's scale, categorized by the number of assets, capital, or employees it owns and the sales it generates (Mulyana & Widyaningsih, 2024; Tonay & Murwaningsari, 2022). The size of a company is relative to its industry and operational characteristics. Bigger companies tend to have more resources, enabling them to carry out and manage green initiatives more effectively (Rahmawati & Sartika, 2025). In this study, company size is determined by the total number of assets owned, as calculated using the following formula (Intan & Paramita, 2025):

$$SIZE = \ln(\text{Total Aset})$$

Companies with large assets tend to have more resources and capabilities to effectively undertake and manage green investments, which require capital and carry high risks (Rahmawati & Sartika, 2025; Sun & Yang, 2022). Therefore, effective green investment can contribute more value to the company as the size of the firm grows (Anggraini & Gunawan, 2024; Sun & Yang, 2022). Previous research by Sun & Yang (2022) demonstrated that the effect of green investment on large companies is more significant than on small-to-medium-sized companies in improving company performance, thereby possibly increasing company value.

H3: Firm Size Strengthens the Effect of Green Investment on Firm Value

Furthermore, larger firms have greater capacity to undertake green innovation because this innovation requires significant costs (Rahmawati & Sartika, 2025). The adoption of green

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innovation in large companies exerts a greater influence on firm value creation by addressing stakeholder demands and signaling positively to investors. This process enhances corporate reputation and public trust, which ultimately contributes to increased company value (Tian et al., 2023). Research by Anggraini & Gunawan (2024), demonstrated that size of the company strengthens the influence of green innovation on company value.

H4: Firm Size Strengthens the Effect of Green Innovation on Firm Value

METHOD

Research Type

This study uses a quantitative research method with a descriptive-causal analysis approach to examine the influence of green practices on corporate value creation, with company size as a moderating variable. The data used are sourced from secondary sources, including the company's financial, sustainability, and annual reports.

Population and Sample

The researcher selected nine companies from the population of 91 energy sector firms listed on the Indonesia Stock Exchange (IDX) between 2018 and 2024 using a purposive sampling method. The criteria for selecting the sample were as follows: (1) Companies that published sustainability reports during the 2018-2024 period and (2) Companies that received a PROPER rating during the 2018-2024 period. The sample selection process is described in Table 1.

Table 1 Sample Selection Process

No.	Description	Total
1	Companies in the energy industry that were publicly traded on the IDX from 2018 to 2024.	91
2	Companies that did not release sustainability reports during between 2018 and 2024.	(80)
3	Companies that did not obtain a PROPER rating during the 2018 to 2024 period.	(2)
Sample Size		9
Observation Data (9 x 7 years)		63

Source: Processed data (2025)

This purposive sampling approach prioritizes data completeness and consistency for all variables. By focusing on nine firms with transparent environmental disclosures, the study minimizes selection bias and ensures that the content analysis is conducted using reliable and accurate data.

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Although the specific sample size may limit generalizability, it is necessary to maintain the rigor and accuracy of the observations within the energy industry.

Research Location

This study is conducted within the Indonesian capital market, focusing on energy sector companies listed on the Indonesia Stock Exchange (IDX). Since the study is based on secondary data, the location refers to the digital access of official reports from the IDX website and the Ministry of Environment and Forestry's PROPER database.

Instrumentation or Tools

The study employed a structured observation sheet to extract secondary data from official sources. Green investment was assessed using PROPER ratings obtained from the Decree of the Minister of Environment and Forestry. These ordinal ratings were transformed into interval data via the Method of Successive Interval (MSI), which utilizes the standard normal distribution to convert categorical proportions into continuous values, thereby ensuring statistical validity for regression analysis (S. N. P. Sari & Paramita, 2025). Green innovation was measured through content analysis based on four specific indicators adapted from Agustia et al. (2019): (1) the adoption of energy-efficient and waste-reducing technologies in production; (2) the utilization of non-hazardous and eco-friendly raw materials; (3) the implementation of sustainable packaging solutions; and (4) the integration of recyclable or reconditioned components within the production cycle. To ensure reliability, a double-check coding procedure was implemented to maintain scoring consistency across all observations. Additionally, firm size was calculated using the natural logarithm of total assets to account for the company's scale. Furthermore, firm value was measured using the Tobin's Q ratio.

Data Collection Procedures

This study employed documentation as the data collection method. Relevant documents, including financial, annual, and sustainability reports, were retrieved from the IDX official website (www.idx.co.id) and the respective companies' websites. Additionally, PROPER ratings were obtained from the Ministry of Environment and Forestry's database (proper.menlhk.go.id).

Data Analysis

Data were analyzed using EViews 13 through a panel data regression approach. This method integrates cross-sectional and time-series data to examine the relationships between the independent and dependent variables. To ensure the most appropriate estimation, model selection

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tests, including the Chow, Hausman, and Lagrange-Multiplier tests, were conducted to choose between Common Effect, Fixed Effect, or Random Effect Models. The study also performed descriptive statistical analysis, classical assumption tests, and the coefficient of determination (R^2) test. Furthermore, Moderated Regression Analysis (MRA) was employed to test the hypotheses. This method utilizes an interaction term to determine whether firm size strengthens or weakens the impact of green investment and green innovation on firm value.

RESULT AND DISCUSSION

Statistics Descriptive Data

Table 2. Descriptive Statistical Analysis Results

	X1_GIE	X2_GIO	Y_FV	Z_SIZE
Mean	2.122704	0.607143	1.012688	31.50608
Median	2.143423	0.750000	0.980674	31.52851
Maximum	3.278328	1.000000	1.602243	32.76456
Minimum	1.000000	0.250000	0.294092	30.08789
Std. Dev.	0.903340	0.204359	0.235637	0.702586
Observations	63	63	63	63

According to the Table 2, the following is a statistical explanation of each variable.

1. The Tobin's Q data range spans from 0.294092 to 1.602243, indicating substantial variation in market valuations across the selected companies. The average value is 1.012688, which is slightly greater than 1, indicating that the average sample of energy companies on the IDX are considered to have future growth prospects.
2. Regarding the green investment variable, the analysis reveals a mean score of 2.122704, which is closely aligned with its median of 2.143423. The intensity of environmental investment within the energy firms shows a significant spread, with observations starting from a low of 1 to a high of 3.278328.
3. The descriptive results for green innovation indicate a mean of 0.607143 and a median of 0.75. This variable, which measures the firms' innovative environmental capabilities, spans from a minimum value of 0.25 to the highest possible score of 1, suggesting varying degrees of green technological adoption.
4. The data show that the mean and median firm size are 31.50608 and 31.52851, respectively. The small gap between the minimum of 30.08789 and the maximum of 32.76456 suggests that the companies in this study have a relatively uniform asset scale.

Panel Data Regression Model Selection Test

Chow Test

Table 3. Chow Test Result

Effects Test	Statistic	d.f.	Prob.
Cross-section F	2.449627843403832	(8,52)	0.0249
Cross-section Chi-square	20.1480156850165	8	0.0098

Source: Processed data (2025)

According to the Chow test, the p-value for the Cross-section Chi-square statistic ($0.0098 < 0.05$). This leads to rejecting H_0 and accepting H_a , indicating that the Fixed Effects Model (FEM) should be preferred over the Common Effects Model (CEM).

Hausman Test

Table 4. Hausman Test Result

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	0.6169	2	0.7346

Source: Processed data (2025)

Based on Table 4 (Hausman test), the prob. value of the Cross-section Random Model ($0.7346 > 0.05$), thus failing to reject the null hypothesis. This means the Random Effects Model (REM) is selected over the FEM.

Lagrange-Multiplier Test

Table 5. LM Test Result

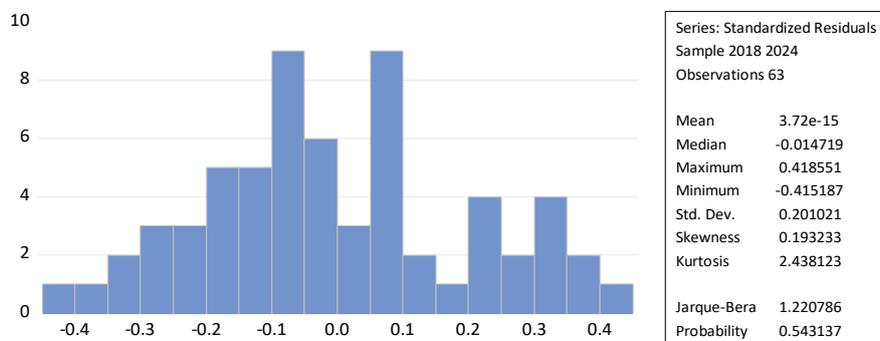
	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	3.8733 (0.0491)	0.5679 (0.4511)	4.4412 (0.0351)

The Lagrange Multiplier test indicates that the REM is preferred. This conclusion is based on the Breusch-Pagan test, which yields a p-value ($0.0351 < 0.05$). As a result, null hypothesis is rejected. Considering the results from these three tests, the Random Effects Model (REM) is the most suitable model for this study.

Classical Assumption Test

Normality Test

Figure 3. Normality Test Result



The Jarque-Bera test results show a p-value of 0.5431, which is greater than the 0.05 threshold. This indicates that the data in this research model is normally distributed, thus meeting the normality assumption and making the model suitable for further analysis.

Multicollinearity Test

Table 6. Multicollinearity Test Result

	X1_GIe	X2_GIo	Z_SIZE
X1_GIe	1.000000	-0.014431	0.620476
X2_GIo	-0.014431	1.000000	-0.039693
Z_SIZE	0.620476	-0.039693	1.000000

Source: Processed data (2025)

Table 6 presents the correlation coefficients among the independent variables, where the correlation between GIe and GIo is -0.0144, GIe and SIZE is 0.6205, and GIo and SIZE is -0.0397. Since all coefficients remain below the 0.90 threshold, the model is free of multicollinearity issues.

Panel Data Regression Analysis

Table 7. Panel Data Regression Analysis Result

Variable	Coefficient	t-Statistic	Prob
C	1.068330	8.913330	0.0000
X1_GIe	-0.118083	-3.437341	0.0011
X2_GIo	0.321199	2.344846	0.0224

Source: Processed data (2025)

$$\text{Tobin's } Q = 1.068330 - 0.118083 \cdot X1_GIe + 0.321199 \cdot X2_GIo + e$$

As shown in Table 7, the constant is 1.068330. Holding all other variables constant, the coefficient for the GIe variable is -0.118083 (p-value = 0.0011 < 0.05), indicating that a one-unit increase in

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Gle is associated with a 0.118 decrease in Tobin's Q. In contrast, the coefficient for the GIO variable is 0.321199 ($p\text{-value} = 0.0224 < 0.05$), suggesting that a one-unit increase in GIO corresponds to a 0.321 increase in the Tobin's Q ratio.

Hypothesis Testing

T Test (Partial)

Table 8 presents the results of the Partial Test (T-Test) conducted in EViews 13, based on Equation 1. The primary focus of this analysis is to determine the individual effect of Gle and GIO on firm value before the inclusion of the moderating variable.

Table 8. Partial Test Results (T Test)

Equation 1			
Variable	Coefficient	t-Statistic	Prob
C	1.068330	8.913330	0.0000
X1_Gle	-0.118083	-3.437341	0.0011
X2_GIO	0.321199	2.344846	0.0224

Source: Processed data (2025)

Based on Table 8, the following is an explanation of the partial (T-test) results for each variable.

1. Green Investment on Firm Value

The probability value ($0.0011 < 0.05$) and the coefficient of -0.118083. Therefore, the null hypothesis is rejected, indicating that Gle has a negative impact on firm value.

2. Green Innovation on Firm Value

With a p-value of 0.0224 and a coefficient of 0.321199, we reject H_0 , confirming that GIO has a positive effect on firm value.

F Test (Simultaneous)

Table 9. Simultaneous Test Results (F Test)

F-statistic	9.178230
Prob(F-statistic)	0.000333

Source: Processed data (2025)

Table 9 presents the results of the simultaneous test, focusing on the Prob(F-statistic) value to determine the collective effect of the independent variables. The table shows the F-statistic value (0.000333, which is < 0.05), therefore, H_a is accepted. This means that green investment and green innovation simultaneously influence firm value at the 5% significance level.

Moderated Regression Analysis (MRA)

The following table (Table 10) presents the results of the Moderation Regression Analysis (MRA) processed in EViews 13 using Equation 2 to identify the moderation categories and Equation 3 to determine the moderating role of size in strengthening or weakening the relationship, as indicated by the interaction variables G_{Ie}_SIZE and G_{Io}_SIZE.

Table 10 MRA Test Result

Variable	Equation 2		Equation 3	
	Coefficient	Prob	Coefficient	Prob
C	0.910102	0.6377	8.234894	0.0550
X1_GIe	-0.119022	0.0041	-5.361968	0.0012
X2_GIo	0.324112	0.0265	3.104356	0.5546
Z_SIZE	0.005029	0.9363	-0.227731	0.0945
G _{Ie} _SIZE	-	-	0.165860	0.0015
G _{Io} _SIZE	-	-	-0.089258	0.5925

Source: Processed data (2025)

Based on the results above, the MRA equation is formulated as follows:

$$\text{Tobin's Q} = 8.234894 - 5.361968 \cdot X1_GIE + 3.104356 \cdot X2_GIO - 0.227731 \cdot Z_SIZE + 0.165860 \cdot GIe_SIZE - 0.089258 \cdot GIo_SIZE + e$$

Based on Table 9, the following is an explanation of MRA test results for each variable.

1. Firm Size Strengthens the Effect of Green Investment on Firm Value

The probability value for company size is 0.9363 (>0.05), indicating that company size has no effect on company value. Meanwhile, the interaction variable G_{Ie}_SIZE shows a probability value of 0.0015 (<0.05) with a positive coefficient value of 0.1659. Because the p-value is less than the 0.05 significance level, then H₀ is rejected. These results indicate that company size strengthens the influence of green investment on company value and functions as a pure moderator.

2. Firm Size Strengthens the Effect of Green Innovation on Firm Value

The analysis indicates that company size does not significantly affect company value, as indicated by a p-value of 0.9363 (>0.05). Similarly, the interaction variable G_{Io}_SIZE yields a p-value of 0.5925, which is also above 0.05, and a negative coefficient of -0.0892. Since the null hypothesis fails to be rejected, company size does not moderate this relationship and is thus classified as a homologizer moderator.

Determination Coefficient Test

Table 11 Determination Coefficient Test Result

R-squared	0.34976
Adjusted R-squared	0.29272

Source: Processed data (2025)

The Adjusted R-squared value from Table 11 is 0.29272, indicating that 29.272% of the variation in firm value is explained by the independent variables, including green investment, green innovation, and the moderating factor of firm size. The remaining variation is attributable to factors not examined in this study.

The Effect of Green Investment on Firm Value

Partial test results demonstrate that green investment had a negative impact on the value of energy industry companies from 2018 to 2024, suggesting that increasing GIe actually reduced firm value. One plausible explanation for this finding is the substantial capital investment required for companies to maintain or enhance their PROPER ratings as part of environmental compliance. Additionally, during the observation period, the energy sector faced considerable market pressure, evidenced by a 0.4% and 17.3% decline in the IDXENERGY index at the outset and continued volatility in subsequent years. This uncertainty prompted investors to perceive significant expenditures on GIe as an added financial burden, potentially diminishing short-term profitability and, consequently, reducing stock demand and company value. These findings are inconsistent with stakeholder and legitimacy theories, which posit that environmentally responsible business practices enhance company value.

These results align with previous studies conducted by Maulana, (2024) and Pardede et al., (2024), which also found that green investment negatively impacts firm value. However, the results are different from those of Paramita & Ali (2023), Putri & Paramita (2025), Sanjaya & Lestari (2025), Tonay & Murwaningsari (2022), and Widarwati et al. (2024), which found that green investment had a positive effect on firm value, and Azhari & Hasibuan (2023) and Hasanah & Paramita (2025), which found that green investment had no effect on firm value. This discrepancy is likely attributable to variations in observation periods and the distinct characteristics of the industrial sectors analyzed.

The Effect of Green Innovation on Firm Value

Partial test results indicate that green innovation positively influences the value of energy companies in Indonesia during the 2018-2024 period. This relationship can be explained by the significant environmental pressures faced by the energy sector. In response, investors perceive green innovation as a strategy to achieve operational efficiency and as a long-term approach to mitigating environmental risks, rather than merely a compliance expense. This provides a positive

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signal to the market that companies are competitive and adaptable in the face of escalating environmental degradation. Consequently, these findings support both signaling theory and legitimacy theory. Successful innovation that reduces negative operational impacts serves as a positive signal and aligns with societal values, ultimately increasing stock demand and company value.

These findings align with earlier studies carried out by Damas et al. (2021), Laela et al. (2024), P. Sari et al. (2024), and F. Zhang et al. (2020). However, they do not align with the results of Xie et al. (2022) and Yao et al., (2019), who concluded that green innovation reduces firm value, nor with the study by Rahelliamelinda & Handoko (2024), which suggested that green innovation has no impact on company value.

The Effect of Green Investment and Green Innovation Simultaneously on Firm Value

Based on the simultaneous F-test, firm value in the energy companies during 2018-2024 is simultaneously influenced by both green investment and green innovation. The phenomenon explaining this result is the synergy between environmental regulatory compliance and value creation through innovative efficiency. While green investment is often perceived as a cost burden, the presence of green innovation provides investors with the expectation that the company can offset these expenditures through increased productivity and reduced long-term ecological risks. Consequently, the integration of these two green initiatives demonstrates a firm's commitment to mitigating its environmental impact, which earns the company stakeholder support and public acceptance. This synergy serves as a positive signal to external parties, particularly investors. As a result, market perceptions of the company's future outlook become more favorable, which, in turn, enhances the company's overall value. These results align with those of Rahmawati & Sartika (2025), which found that both green investment and green innovation affect a firm's value.

The size of the firm moderates the effect of green investment on firm value.

The results of the Moderated Regression Analysis (MRA) indicate that firm size strengthens the influence of green investment on firm value, supporting the hypothesis based on signaling and legitimacy theory. This finding suggests that the impact of green investment is more pronounced in larger firms, as they typically possess greater resource capacity and financial stability to implement environmental initiatives more efficiently. While green investment initiatives require substantial capital and may initially be perceived as a financial burden or cost that reduces profitability, larger companies are seen as more financially resilient. Investors perceive firms with larger asset bases as being better able to absorb these costs without affecting core operations. Additionally, due to their greater public visibility, green investments by larger companies serve as a stronger signal of legitimacy to stakeholders. Consequently, the market responds more favorably when such investments are undertaken by large companies that possess the managerial expertise and resources to convert compliance costs into long-term business sustainability. This finding does not support the previous study by Rahmawati & Sartika (2025), which found that company size did not moderate the effect between green investments and firm value.

The size of the firm moderates the effect of green innovation on firm value.

The findings from the MRA test indicate that the impact of green innovation on firm value is not influenced by the company's size. This finding does not support H4, which suggests that the green innovation and firm value effect can be strengthened by firm size. This suggests that the positive effect of green innovation on company value is consistent for both large and small firms. This phenomenon can be explained by the perspective that investors regard green innovation as a source of efficiency and competitive advantage, which does not necessarily depend on the scale of a company's physical assets. In contrast to green investment, which often requires substantial capital expenditures and thus makes financial capacity more critical, green innovation focuses on operational process improvements to reduce environmental impacts, such as hazardous waste management. Consequently, investors tend to value environmentally friendly innovation efforts regardless of company size, as such initiatives signal a company's adaptability in addressing long-term environmental challenges. This finding supports Tonay & Murwaningsari's (2022) finding, but is inconsistent with Anggraini & Gunawan's (2024), which found that firm size strengthens the influence of green innovation on firm value.

CONCLUSION

This study examines the influence of green investment and green innovation on firm value, and the role of company size as a moderating variable in energy sector companies listed on the Indonesia Stock Exchange (IDX) for the 2018-2024 period. The results show that green investment negatively affects firm value, whereas green innovation positively affects firm value. This suggests that investors view green investment as a financial burden that reduces short-term profits, potentially reducing stock demand and firm value, whereas green innovation is perceived as a strategic initiative to increase long-term value. Simultaneously, both initiatives influence firm value. Furthermore, company size has been shown to strengthen the influence of green investment on firm value, but does not moderate the effect of green innovation. Large companies can leverage their resources to offset the initial negative impact of green investments, while green innovation consistently drives value regardless of company size.

Based on these findings, energy sector companies are advised to shift their focus to increasing the efficiency of green investment spending. Given that green investment is currently perceived as a cost burden, management should prioritize high-efficiency investments to ensure that compliance costs can be translated into operational savings. Companies should also continue to prioritize innovations in production processes that can reduce environmental risks while increasing productivity. Large companies, in particular, should leverage their superior resource capacity to enhance the effectiveness of green investment in optimizing company value.

Despite the findings, this study has several methodological limitations. First, the small sample size of nine companies may introduce selection bias and limit the generalizability of the results to the entire energy industry. Second, the validity of the proxies used for green innovation may not fully capture the complexity of environmental strategies. Third, the moderation model specification in this study is limited to firm size. Future research is recommended to expand the sample size to

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include various industry sectors and a longer observation period to better understand the long-term impact of green initiatives. Furthermore, future researchers are encouraged to explore alternative moderating or mediating variables, such as profitability, corporate governance, or environmental performance ratings, to provide a more comprehensive understanding of environmental factors and firm value.

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