

Eco-efficiency, Carbon Emissions, and Green Innovation on Firm Value: The Moderating Role of Environmental Performance in Indonesia

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ABSTRACT

Many companies in Indonesia have implemented eco-efficiency through ISO 14001 certification, disclosed carbon emissions in sustainability reports, and claimed to engage in green innovation, but their market value does not consistently respond to these commitments. This study analyzes the effect of eco-efficiency, carbon emissions, and green innovation on firm value, and examines the moderating role of environmental performance measured by PROPER. The research was conducted on companies listed on the Indonesia Stock Exchange during 2021-2023, using secondary data from annual and sustainability reports. A purposive sampling method resulted in 73 companies with 219 observations, analyzed using panel data regression with a Fixed Effect Model. The results show that eco-efficiency has a negative effect, while carbon emissions and green innovation have no significant effect. Environmental performance does not moderate the effect of eco-efficiency or carbon emissions, but strengthens the effect of green innovation on firm value, indicating that green innovation's effectiveness depends on externally verified environmental performance. These results imply that companies should pair green innovation with verified environmental performance such as PROPER, rather than relying on eco-efficiency certification alone, to gain investor recognition, while investors and regulators can use PROPER ratings to assess the credibility of corporate sustainability claims.

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INTRODUCTION

Firm value is an important indicator that reflects how the capital market assesses a company's overall performance and future prospects ([Harnida et al., 2021](#)). Firm value is important for companies because it reflects investors' expectations regarding the company's ability to generate economic benefits and maintain business continuity in the future. In the capital market, investors assess companies not only based on their current financial performance but also on their prospects, risks, and ability to respond to changes in the business environment ([Agung & Satia, 2026](#)). Therefore, maintaining and increasing firm value is an important concern for companies because market valuation reflects the extent to which investors recognize the company's performance and future potential. However, amid increasing economic and environmental pressures, maintaining firm value is becoming more challenging because companies are required to balance the pursuit of economic benefits with growing demands for responsible and sustainable business practices ([Purnami et al., 2023](#)). Environmental risks arising from corporate activities can affect operational continuity, resource availability, reputation, and long-term business prospects, which may subsequently influence investors' assessment of the company ([Hindria, 2023](#)). One of the major environmental pressures facing companies today is the increasing impact of climate change and global warming, which is closely associated with



greenhouse gas emissions. Thus, the ability of companies to respond to environmental pressures becomes increasingly relevant to the market's assessment of firm value.

The increase in global average temperatures in recent decades further reinforces that climate change caused by global warming, which is the effect of greenhouse gases, is no longer an issue that can be ignored but a real threat to the sustainability of ecosystems and economic activity ([Bilgili et al., 2024](#)). [Damas et al. \(2021\)](#), noted that greenhouse gases such as carbon dioxide (CO₂), methane (CH₄), nitrous oxide (N₂O), and fluorinated compounds are known to amplify the greenhouse effect and accelerate environmental degradation by trapping these gases, causing extremely severe climate change. The impacts of climate change have affected natural resource availability, increased disaster risks, and difficulty in obtaining global supply chains ([Cevik, 2024](#)). Industrial activity has become a major contributor to environmental damage by triggering the presence of these gases, so governments and companies are required to adopt sustainable business practices that are not only oriented toward economic growth but also environmental protection.

Indonesia, as a developing country and considered to be the lungs of the world, indeed also contributes to global carbon emissions and greenhouse gases due to economic activities that continue to increase ([Ladista & Syaipudin, 2023](#)). Based on GoodStats data (2023), Indonesia ranked among the ten countries with the highest CO₂ emissions in the world, ranking seventh in 2022 with emissions reaching 839.6 million tons of CO₂. Carbon emissions increased by 27.73% compared with the previous year, with the energy and industrial sectors contributing substantially to national emissions. This condition has encouraged the Indonesian government to strengthen environmental policies and regulations through Law No. 32 of 2009 concerning Environmental Protection and Management, Government Regulation No. 98 of 2021 concerning the Economic Value of Carbon and the Control of Greenhouse Gas Emissions, as well as environmental performance assessment through the Corporate Performance Rating Program (PROPER). PROPER serves as an instrument for evaluating corporate environmental performance and provides an externally assessed indication of companies' environmental performance ([Marlina & Herawaty, 2024](#)). Therefore, corporate environmental performance in Indonesia is not only related to regulatory compliance but also provides information that can shape stakeholder perceptions and investors' assessment of companies.

In response to these environmental pressures, companies can adopt environmental strategies that are integrated into their operational activities, including eco-efficiency, carbon emissions disclosure, and green innovation. Eco-efficiency emphasizes reducing resource use and waste through improvements in production processes, allowing companies to generate greater output with lower environmental impacts. Such improvements can enhance operational efficiency and potentially strengthen investors' assessment of the company's performance and future prospects, thereby contributing to firm value ([Majid et al., 2023](#)). Carbon emissions disclosure represents a form of transparency and accountability through which companies communicate information regarding the amount, sources, and management of emissions resulting from their operational activities ([Comello et al., 2023](#)). By providing investors with information regarding the company's exposure to and management of environmental risks, carbon emissions disclosure may influence market perceptions and firm value ([Hadiani & Mulyani, 2023](#)). Meanwhile, green innovation complements these strategies through the development of environmentally friendly technologies, products, and production processes that can support long-term efficiency and competitiveness ([Drakul, 2025](#)). These benefits may improve investors' perceptions of the company's future prospects and consequently affect firm value.

Nevertheless, the implementation of environmental strategies does not necessarily generate a uniform market response. Eco-efficiency may improve resource efficiency and reduce environmental impacts, but the benefits may require time to materialize. Carbon

emissions disclosure can increase transparency, but disclosure alone does not necessarily demonstrate superior environmental performance. Similarly, green innovation can support long-term competitiveness but may require substantial investment before generating economic benefits. Environmental strategies may therefore produce both potential benefits and costs for companies, which can lead to different implications for investors' assessments of firm value. The costs associated with environmental standards, production technologies, and environmental management systems may increase operational burdens and potentially reduce short-term profitability, which may subsequently affect firm value [Mishelle \(2023\)](#); [Dinniyah & Nuzula \(2021\)](#).

Inconsistencies in the results of previous studies indicate a relationship between sustainability strategy and firm value are inconclusive. [Marlina & Herawaty \(2024\)](#); [Zahraisha & Hapsari \(2025\)](#); [Damanik & Prihandini \(2025\)](#), which state that eco-efficiency has a positive effect on the company. Meanwhile, different results were found by [Hikmah & Akib \(2025\)](#); [Wasyiah et al. \(2025\)](#); [Kurniasari & Cahyono \(2025\)](#), which states that eco-efficiency has no effect on firm value. Similar inconsistencies occur in carbon emissions and green innovation. Based on these inconsistent research results, it is allegedly caused by the neglect of contextual factors that determine whether sustainability signals can be captured positively by the market.

One contextual factor that may explain these differences is externally recognized environmental performance. Environmental strategies implemented or disclosed by companies may not receive the same response from investors when there is limited evidence regarding their actual environmental performance. In this context, PROPER provides an externally assessed indication of corporate environmental performance that differs from environmental information voluntarily disclosed by companies. Companies with better PROPER ratings provide stronger external evidence that their environmental commitments are accompanied by actual environmental performance. Conversely, environmental strategies implemented by companies with weaker environmental performance may provide less convincing information to the market. Therefore, PROPER-based environmental performance may strengthen or weaken the relationship between eco-efficiency, carbon emissions disclosure, green innovation, and firm value.

Based on this gap, this study examines the effects of eco-efficiency, carbon emissions disclosure, and green innovation on firm value and further investigates the moderating role of PROPER-based environmental performance. The use of PROPER as a moderating variable provides a contextual perspective for explaining why similar environmental strategies may receive different market responses. Theoretically, this study contributes to the sustainability literature by examining the conditional relationship between corporate environmental strategies and firm value through externally assessed environmental performance. Practically, the findings provide implications for companies, investors, and regulators in understanding how environmental strategies and externally recognized environmental performance may influence firm value.

This study adopts legitimacy theory and signaling theory as its theoretical framework. Signaling theory was first introduced by [Spence in 1978](#), asserting that a signal is only considered effective if the information genuinely and accurately reflects the company's quality and performance. Companies with good performance tend to be more transparent because such transparency strengthens positive market perceptions. This is in line with [Aulia et al. \(2024\)](#), who state that companies confident in their quality are encouraged to disclose more information as a way to differentiate themselves from other companies, such as through carbon emission disclosure, ISO certification, and green innovation. Companies that disclose emission data and their reduction efforts want to show that they act responsibly and are capable of managing their environmental impact. [Hapsoro & Adyaksana \(2020\)](#), state that such signals are difficult to imitate by companies that do not have adequate environmental performance, making them a relatively credible indicator for investors when making investment decisions. Thus, signaling theory supports the

relationship in which disclosure of sustainability information and green innovation can enhance investor perception and ultimately increase firm value. Legitimacy theory explains that companies need to maintain social acceptance by aligning their activities with societal values and norms. Legitimacy was first proposed by [Dowling in 1975](#), who stated that a company will always strive to ensure that its activities are in line with the values, rules, and expectations of the society in which it operates. By maintaining this alignment, companies can sustain the social acceptance that underlies the continuity of their activities. Legitimacy emphasizes that a company will achieve sustainability if society understands that the company's activities are consistent with societal values and norms ([Rochayatun et al., 2021](#)). [Moussa et al. \(2022\)](#), explain that disclosing environmental performance information in corporate reporting can strengthen the perception that business activities are not in conflict with society. Disclosing environmental performance through the implementation of *eco-efficiency* and green innovation demonstrates a good corporate image in the eyes of the public ([Damanik & Prihandini, 2025](#)). Thus, through public legitimacy, companies gain market support that is reflected in an increase in firm value.

Firm value is a way for the market to assess a company's overall performance, including its ability to generate profits and sustain its business ([Bhinuko et al., 2025](#)). This value is reflected through investor responses in the capital market, so the better the investor perception, the higher the firm value. [Kamilla \(2025\)](#), states that firm value is influenced by various factors related to business strategy, governance quality, and corporate commitment to maintaining environmental sustainability. Companies that are able to demonstrate good environmental performance do so through various sustainability practices integrated into their operational activities, such as *eco-efficiency*, green innovation, and carbon emission disclosure, which tend to be more valued by the market, because such information is used by investors as a basis for assessing business prospects and long-term risk, so that companies that consistently implement and disclose sustainability practices obtain more positive market valuations. This is in line with research conducted by [Hapsoro & Adyaksana \(2020\)](#), namely that companies that manage their environmental impact well generally receive a more positive market valuation through environmental performance disclosure.

Eco-efficiency explains how companies strive to align economic performance and environmental responsibility within a more efficient operating system ([Damas et al., 2021](#)). In practice, companies that implement *eco-efficiency* drive reductions in energy consumption, raw materials, and waste processing costs, thereby directly lowering costs. This cost reduction improves production efficiency and company profitability, thereby improving financial performance, which forms the basis for an increase in firm value ([Savitri et al., 2023](#)). Based on legitimacy theory, environmental efficiency practices help companies demonstrate compliance with societal norms and demands related to environmental management, thereby reducing the risk of sanctions, public pressure, and operational disruption ([Moussa et al., 2022](#)). [Majid et al. \(2023\)](#), state that companies in high-risk sectors, particularly those related to emissions, tend to increase *eco-efficiency* practices to reduce public criticism and maintain social trust in the company's sustainability. Improved environmental efficiency serves as a positive signal to investors regarding the quality of management and the company's ability to effectively manage costs and environmental risk. This signal reduces investor risk perception and increases confidence in future profit and cash flow prospects. This condition drives increased public trust in the company, which is ultimately reflected in an increase in firm value. This is confirmed by [Zahraisha & Hapsari \(2025\)](#) who found that environmental efficiency strengthens the market's view of a company's long-term prospects because it demonstrates the quality of the company's commitment and governance regarding environmental issues.

H₁ : Eco-efficiency has a positive effect on firm value

Carbon emissions are one indicator for assessing how much a company's activities contribute to climate change ([Ladista & Syaipudin, 2023](#)). The high level of public attention

to environmental issues makes the management and disclosure of carbon emissions important for companies. Legitimacy theory explains that carbon emission disclosure is also a way for companies to build public legitimacy and create a good corporate image in the eyes of society, as it aligns with public demands for companies to care about the environment ([Ammer et al., 2020](#)). In addition to influencing corporate image, managing and reducing carbon emissions has direct consequences for environmental regulatory risk and potential claims that companies may face. As environmental regulations become stricter, companies with lower emission levels tend to face lower sanctions, fines, and compliance costs, and reduce the potential for legal claims due to environmental damage. Based on signaling theory, disclosure and efforts to reduce carbon emissions serve as a positive signal to investors, as they reflect the company's ability to manage non-financial risk that affects future business prospects. Research conducted by [Hadianti & Mulyani \(2023\)](#), confirms that companies actively reducing carbon emissions tend to receive better market valuations because they are considered to have more stable and sustainable long-term prospects.

H₂ : Carbon emission disclosure has a positive effect on firm value

Legitimacy theory, according to [Dowling, 1975](#), explains that a company's sustainability depends heavily on its ability to align its business with the rules applicable in society. One practice that can be implemented is green innovation, which can minimize the environmental impact of company activities and indirectly increase firm value. Green innovation is a company's effort to update technology or production processes in order to reduce environmental impact ([Drakul, 2025](#)). Currently, many companies have been encouraged to develop innovations in order to maintain public acceptance and demonstrate that their operational activities are moving toward sustainability ([Ammer et al., 2020](#)). Research conducted by [Damas et al. \(2021\)](#), shows that companies adopt green innovation to strengthen their position in the eyes of the public while responding to criticism regarding the level of emissions they generate. By doing so, companies not only ease public concerns but also help demonstrate their commitment to sustainability. [Octavianingrum et al. \(2024\)](#), state that the market responds positively to companies that actively innovate in an environmentally friendly manner, as innovation is one indicator of company performance quality in facing future competitiveness.

H₃ : Green innovation has a positive effect on firm value

[Hadianti & Mulyani \(2023\)](#) state that environmental performance is a company's success in managing the operational impact on the environment. Companies with good environmental records usually gain public acceptance because society sees that their business activities do not neglect ecological responsibility ([Gudio, 2025](#)). Companies that receive high environmental ratings are more valued by the public, especially when the company operates and has a significant impact on environmental damage ([Yu et al., 2021](#)). Good environmental performance is often interpreted by investors as a sign that the company implements a solid risk management control system. [Moussa et al. \(2022\)](#), explain that companies with consistently good environmental performance are perceived as more stable because they are able to cope with potential costs and regulatory pressure. Such assessments require indicators that are not merely declarative but are able to genuinely reflect a company's environmental compliance and performance; in this case, PROPER meets these characteristics, as it measures environmental performance directly, objectively, and is verified through compliance audits and field evaluations by the Ministry of Environment and Forestry. This differs from other indicators such as ESG, which heavily rely on voluntary management reports and are vulnerable to narrative manipulation, *greenwashing* practices, and managerial interests. This is reinforced by research from [Hardiyansah & Agustini \(2021\)](#), which explains that companies with good environmental performance are able to increase the effectiveness of sustainability strategies such as energy efficiency, emission disclosure, and green innovation, because the market perceives alignment between operational practices and the company's long-term

commitment. Thus, through the implementation of environmental performance, companies are able to increase their value in the eyes of the public. A high environmental performance achievement as a moderating variable ensures that a company's sustainability strategy practices are credible and not merely image building. This investor confidence strengthens the positive impact of sustainability implementation on the significant increase in firm value.

H₄ : Environmental performance strengthens the effect of eco-efficiency on firm value

H₅ : Environmental performance strengthens the effect of carbon emission disclosure on firm value

H₆ : Environmental performance strengthens the effect of green innovation on firm value

Based on the hypotheses above, the conceptual framework can be illustrated in Figure 1.

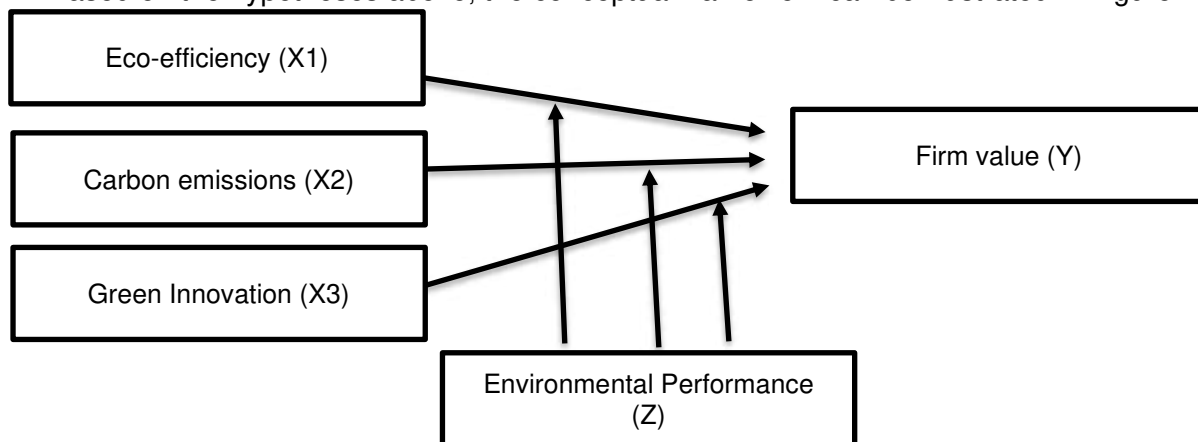


Figure 1. Conceptual Framework

Source: Data processed by researchers (2026)

METHODS

This study uses a quantitative approach with an associative design. The research data consists of secondary data obtained through documentation methods. The population in this study is all companies listed on the Indonesia Stock Exchange during the 2021-2023 period, totaling 903 companies. The sample was determined using a purposive sampling technique with the following criteria: 1. companies listed on the IDX during 2021-2023, 2. companies that consecutively published accessible annual and sustainability reports during that period, 3. companies with complete financial and environmental data, 4. companies registered in PROPER, and 5. companies with available market data for calculating firm value (Tobin's Q). Based on these criteria, a sample of 73 companies with a total of 219 observations was obtained. The data analysis technique consists of descriptive statistics, determination of the best estimation model, classical assumption testing, and panel data analysis. The analysis was conducted using STATA software.

This study uses two regression models to answer the research hypotheses. Model 1 is used to test the direct effect without the moderating variable, using the following equation:

$$FM = \beta_0 + \beta_1 ECOEF + \beta_2 CEM + \beta_3 GI + \varepsilon$$

Model 2 is used to test the moderating role of environmental performance by adding an interaction term, using the Moderated Regression Analysis (MRA) equation as follows:

$$FM = \beta_0 + \beta_1 ECOEF + \beta_2 CEM + \beta_3 GI + \beta_4 EP + \beta_5 ECOEF \times EP + \beta_6 CEM \times EP + \beta_7 GI \times EP + \varepsilon$$

Notes: FM = Firm Value ; 0 = Constant; ECOEF = Eco-efficiency; CEM = Carbon Emissions; GI= Green Innovation; EP = Environmental Performance; ε = error term.

Table 1. Operational Definition of Variables

Variable	Indicator	Measurement Scale	Reference
Firm Value	$Q = \frac{(MVE + D)}{(BVE + D)}$	Ratio	Octavianingrum et al. (2024) ; Hikmah & Akib (2025) ; Resti Kurniasari & Yuli Tri Cahyon (2025)
Eco-efficiency	ISO 14001 certification, measured with a dummy: companies that hold it receive a score of 1, and those that do not receive a score of 0 (nominal scale).	Nominal	Marlina & Herawaty (2024) ; Damas et al. (2021) ; Damanik & Prihandini (2025)
Carbon Emissions	18 disclosure items, scored 1 if an item is present and 0 if not disclosed; the number of items disclosed is then divided by the total number of disclosure items, following the formula $CEDI = (\sum di / 18)$, where $di = 1$ if disclosure item i is disclosed and 0 if not disclosed (ratio scale).	Ratio	Aulia et al. (2024) ; Zahraisha & Hapsari (2025) ; Ladista & Syaipudin (2023)
Green Innovation	4 environmentally friendly disclosure items, scored 1 if found and 0 if not. The level of green innovation disclosure is calculated by dividing the number of disclosed indicators by the total indicators used, following the formula $GII = (\sum gi / 4)$, where $gi = 1$ if green innovation indicator i is disclosed and 0 if not disclosed (ratio scale).	Ratio	Octavianingrum et al. (2024) ; Drakul (2025)
Environmental Performance	PROPER score from 1 to 5 according to color rating (ordinal scale): Gold = 5 (has consistently demonstrated environmental excellence, applied international-standard environmental management, and carried out community development programs); Green = 4 (has exceeded the compliance requirements set out in the regulations, e.g., through waste reduction, reuse, and recycling/3R); Blue = 3 (has complied with prevailing environmental laws and regulations); Red = 2 (environmental management efforts are underway but do not yet fully comply with the regulations); Black = 1 (has deliberately committed a violation, has not undertaken required environmental management efforts, or has caused environmental damage).	Ordinal	Marlina & Herawaty (2024) ; Rusmana & Purnaman (2020)

Source: processed data (2026)

RESULTS AND DISCUSSION

Table 2 presents the descriptive statistics of all research variables, as follows:

Table 2. Descriptive Statistics

Variable	N	Mean	Std. Dev.	Min	Max
Firm Value	219	1.491	1.309	0.385	10.570
Eco-efficiency	219	0.662	0.474	0	1
Carbon Emissions	219	0.713	0.219	0.222	1
Green Innovation	219	0.681	0.212	0.25	1
Environmental Performance	219	3.315	0.618	3	5

Source: processed data (2026)

Table 3. Frequency Distribution of Eco-efficiency and Environmental Performance

Variable	Category	Freq.	Percent (%)
Eco-efficiency	0	74	33.79
	1	145	66.21
Environmental Performance	3	168	76.71
	4	33	15.07
	5	18	8.22

Source: processed data (2026)

The average value of Tobin's Q is 1.491, with a standard deviation of 1.309, a minimum value of 0.385, and a maximum value of 10.570, indicating considerable variation in market valuation. This average Tobin's Q indicates that, in general, the market value of the sample companies exceeds their asset book value. The average *eco-efficiency* value of 0.662 means that, as detailed in table 3, 145 observations (66.21%) hold ISO 14001 certification, while the remaining 74 observations (33.79%) do not. Carbon emissions have an average disclosure index of 0.713, with a standard deviation of 0.219, a minimum value of 0.222, and a maximum value of 1, meaning that, on average, sample companies disclosed 71.3% of the total carbon emission disclosure items, ranging from 22.2% to 100% across companies. This indicates a relatively high level of carbon emission disclosure among the sample companies. Green innovation has an average of 0.681, with a standard deviation of 0.212, a minimum value of 0.250, and a maximum of 1, meaning that, on average, sample companies disclosed 68.1% of the total green innovation indicators, ranging from 25.0% to 100% across companies. This value indicates that companies have implemented green innovation practices. Environmental performance has an average of 3.315, with a minimum value of 3 and a maximum value of 5, indicating that all sample observations are rated at least at the blue level, the basic rating for companies that have met environmental management requirements in accordance with applicable regulations, and that none of the 219 observations received a red or black rating. As shown in table 3, of the 219 observations, 168 observations (76.71%) are rated blue, 33 observations (15.07%) are rated green, and 18 observations (8.22%) are rated gold, reflecting that only a small proportion of companies (23.29%) have carried out environmental management beyond mandatory requirements, while the environmental performance of the sample companies in general remains concentrated at the basic compliance level.

Prior to model estimation, a panel model selection process was carried out: the Chow test produced $F(72,139) = 15.20$ ($p = 0.000$), the Hausman test produced $\chi^2(7) = 20.71$ ($p = 0.004$), and the LM test produced $\chi^2(01) = 135.20$ ($p = 0.000$). All tests directed the selection toward the Fixed Effect Model (FEM) as the main estimation model.

Classical assumption testing was carried out on the FEM model residuals to ensure the quality of the estimation. The normality test using Skewness-Kurtosis produced a value of $\chi^2 = 23.29$; $p = 0.000$, indicating that the residuals are not normally distributed. However, with 219 observations, this assumption can be disregarded based on the Central Limit Theorem, which states that the sampling distribution approaches normality in large

samples ($n > 30$), so the estimation results remain valid ([Knief, 2021](#)). The average VIF of 1.96, below 10, confirms the absence of multicollinearity. The Breusch-Pagan test result of $\chi^2 = 38.55$; $p = 0.000$ indicates the presence of heteroskedasticity, so robust standard errors were used in the estimation to address this. The autocorrelation test using the Baltagi-Wu method ($LB1 = 2.406$) and Bhargava et al. ($DW = 1.610$) shows that both values are close to 2, indicating no autocorrelation in the model.

Table 4 presents the results of multiple linear regression using Fixed Effect Model estimation with robust standard errors, used to test the direct effect of *eco-efficiency*, carbon emissions, and green innovation on firm value, before considering the interaction effects.

Table 4. Multiple Linear Regression Results

Variable	Coeff.	t-Stat.	Prob.
Constant	-0.912	1.79	0.078
Eco-efficiency	-0.157	-2.70	0.009
Carbon Emissions	-0.219	-0.54	0.592
Green Innovation	-0.239	-0.88	0.384
R ²	0.028		
F-count Value	2.30		
Sig. F	0.067		

Source: processed data (2026)

The F-test result ($\text{Prob} > F = 0.067$) indicates that the independent variables do not jointly explain firm value at the 5% significance level. The low R² of 0.028 indicates that only 2.8% of the variation in firm value is explained by the variables included in the model. This may occur because firm value is influenced by various financial, market, and firm-specific factors that are not included in Model 1. In addition, Model 1 examines only the direct relationships between environmental variables and firm value, whereas this study proposes that the effect of environmental strategies may depend on environmental performance. Therefore, rather than increasing the tolerance value to obtain a significant model, the analysis proceeds to Model 2 by incorporating environmental performance as a moderating variable and its interaction terms. Future research may further improve the explanatory power of the model by including relevant control variables and extending the observation period.

Eco-efficiency shows a coefficient of -0.157 with $t = 2.70$ and $p = 0.009 < 0.05$ in Model 1, so H1 is rejected. Eco-efficiency has a significant negative effect on firm value. This means that as companies implement eco-efficiency, firm value decreases. This finding indicates that the implementation of eco-efficiency, proxied through ISO 14001 ownership, has not been perceived by investors as a factor capable of increasing firm value. The increasingly common adoption of environmental management practices among companies has caused ISO 14001 certification to no longer be seen as a new signal to the market. Investors tend to pay more attention to information directly related to profit prospects and financial performance compared to environmental indicators whose economic benefits cannot yet be directly observed ([Dinniyah & Nuzula, 2021](#)). This condition is exacerbated by the fact that the cost of implementing ISO 14001 certification, such as audits, training, and adjustments to environmental management systems, suppresses company profitability. In the short term, the market tends to view the costs incurred as more dominant than future economic benefits, so investors who see a company holding ISO certification are not immediately interested in investing in it. From the perspective of legitimacy theory, companies often adopt environmental practices to meet stakeholder expectations and obtain social legitimacy, but this legitimacy does not always translate into an increase in firm value in the capital market ([Baloch & Awais, 2020](#)). This research result is consistent with [Hikmah & Akib \(2025\)](#); [Wasyiah et al. \(2025\)](#); and [Kurniasari & Cahyono \(2025\)](#).

Carbon emission disclosure obtains a coefficient of -0.219 with $t = -0.54$ and $p = 0.592$

> 0.05 , so H2 is rejected. Carbon emission disclosure has no significant effect on firm value. This result indicates that carbon emission disclosure has not yet become a consideration for investors in valuing companies. This is because carbon emission disclosure demonstrates corporate transparency more than it demonstrates a company's ability to increase its profitability. According to signaling theory, information will be responded to by the market if the information is considered relevant and trustworthy in predicting a company's prospects ([Hadianti & Mulyani, 2023](#)). However, carbon emission disclosure in Indonesia is still voluntary and does not yet require third-party assurance, making it difficult to ensure the accuracy and consistency of the emission figures reported by companies. [Gipper et al. \(2025\)](#), state that third-party assurance plays an important role in increasing investor confidence, so without such assurance, carbon emission disclosure tends to be viewed as a unilateral disclosure by the company that does not necessarily reflect actual conditions. As a result, investors remain hesitant to invest in the company. [Emrinaldi & Agri \(2021\)](#), also explain that carbon emission disclosure does not always receive a positive market response, particularly when the information conveyed is not yet considered material to company performance. This finding is reinforced by the fact that investors predominantly still prefer to look at financial-based company performance rather than non-financial performance such as carbon emission disclosure ([Ladista & Syaipudin, 2023](#)). This result is consistent with and [Shafira \(2024\)](#).

Green innovation shows a coefficient of -0.239 with $t = -0.88$ and $p = 0.384 > 0.05$, so H3 is rejected. Green innovation has no significant effect on firm value. This study shows that the market has not yet responded positively to green innovation, even though it is viewed as a strategy that can improve long-term efficiency and sustainability. However, this is due to the high costs required to implement green innovation, which suppress company profitability. This finding is supported by signaling theory, namely that a signal is considered effective if it provides investors with confidence about the company's future performance ([Spence, 1978](#)). However, this cannot be observed by investors because the economic results of green innovation are generally difficult to observe in the short term, as the effect of green innovation on firm value is often not visible due to the time lag between innovation investment and its economic benefits. In addition, the measurement of green innovation in this study is based on the success of innovation in generating economic benefits, so a high level of green innovation is not necessarily immediately captured by the market. This result is in line with [Wijayanti & Budi \(2024\)](#) and [Nurjannah et al. \(2025\)](#).

Table 5 presents the main regression results of this study, namely the Moderated Regression Analysis.

Table 5. Moderated Regression Analysis (MRA) Test Results

Variable	Coeff.	t-Stat.	Prob.
Constant	0.112	0.23	0.819
Eco-efficiency	-0.129	-1.46	0.150
Carbon Emissions	-0.191	-0.50	0.619
Green Innovation	-0.296	-1.55	0.126
Environmental Performance	0.153	1.52	0.133
ECOEFxEP	0.242	1.22	0.227
CEMxEP	-0.390	-1.97	0.053
GlxEP	1.970	3.53	0.001
R ²	0.152		
F-count Value	3.56		
Sig. F	0.002		

Source: processed data (2026)

Different results were found in Table 4 after the interaction variables were added, where the F test shows a different result, namely $F(97,139) = 3.56$ with $\text{prob} > F = 0.002 < 0.05$. This means that simultaneously, all independent variables *eco-efficiency*, carbon

emissions, green innovation, environmental performance, and the three interaction variables have a significant effect on firm value. The R^2 value of 0.152, five times higher than in Model 1, indicates that the research variables, after the addition of the interaction variables, are able to explain 15.21% of the variation in firm value.

The interaction between *eco-efficiency* and environmental performance obtains a coefficient of 0.242 with $t = 1.22$ and $p = 0.227 > 0.05$, so H4 is rejected. Environmental performance is not proven to strengthen the effect of *eco-efficiency* on firm value. The insignificance of this moderation result indicates that the combination of ISO 14001 ownership and PROPER rating does not provide additional value or information capable of increasing firm value. When investors already possess PROPER information as a more comprehensive and independently government-verified environmental performance signal, the addition of the ISO 14001 signal no longer provides sufficiently strong new information to influence investment decisions. This argument is in line with Salehi et al. (2017) who found that not all combinations of moderating variables produce a significant effect, as their effectiveness strongly depends on the institutional context and the level of investor sophistication in the market studied.

The interaction between carbon emission disclosure and environmental performance obtains a coefficient of -0.390 with $t = -1.97$ and $p = 0.053$, so H5 is rejected. Environmental performance is not proven to strengthen the effect of carbon emission disclosure on firm value. This research result shows that once a company has obtained a good PROPER rating, investors tend to assume that information regarding the company's environmental management is already reflected in that PROPER rating, so additional emission disclosure no longer provides benefits to investors. This finding is further reinforced by the fact that the average PROPER rating among the sample companies is at the blue level, while the number of green and gold ratings is relatively small. This condition indicates that the level of truly outstanding environmental performance remains well below average. As a result, information from carbon emission disclosure and PROPER ratings has not yet been able to form a combined signal strong enough to influence investor perceptions of firm value. This result is in line with [Damas et al. \(2021\)](#), [Gayatri & Yuniarta \(2024\)](#), dan [Rahmasari \(2024\)](#).

The interaction between green innovation and environmental performance has a positive coefficient of 1.970 with $t = 3.53$ and $p = 0.001 < 0.05$, so H6 is accepted. Environmental performance is proven to strengthen the effect of green innovation on firm value. This is the main contribution of this study. The positive coefficient of 1.970 means that when green innovation increases by one unit in a company with high environmental performance, firm value increases by 1.970 units an economically substantial and meaningful effect. This finding reveals an important mechanism: green innovation alone, without a high PROPER rating, is not sufficiently convincing to the market, but when green innovation is accompanied by externally verified environmental performance through PROPER, the combination produces a strong signal that is trusted by investors ([Xie et al., 2022](#)). From the perspective of signaling theory, PROPER functions as evidence that validates a company's green innovation claims. Investors who were initially doubtful about green innovation disclosure out of concern that a company merely discloses without implementing it, or reports without taking real action become more confident in such claims through the government's objective assessment via PROPER. The combined signal of high green innovation and PROPER creates a strategic effect that drives positive investor perceptions and ultimately genuinely increases the company's market value. From the perspective of legitimacy theory, companies that successfully combine green innovation with verified environmental performance obtain dual legitimacy market legitimacy through the green innovation signal and institutional legitimacy through government recognition via PROPER which together strengthen the trust of stakeholders, including investors. This result is consistent with [Hardiyansah & Agustini \(2021\)](#); [Damas et al. \(2021\)](#); dan [Damanik & Prihandini \(2025\)](#) who assert that companies with verified environmental performance

are able to increase the effectiveness of their sustainability strategies because the market perceives consistent alignment between operational practices and the company's long-term commitment to environmental sustainability.

CONCLUSION

The findings of this study show that *eco-efficiency* has a negative effect, while carbon emission disclosure and green innovation are not proven to affect firm value. PROPER-based environmental performance is also not proven to strengthen the effect of *eco-efficiency* and carbon emission disclosure on firm value; the only hypothesis accepted is that environmental performance significantly strengthens the effect of green innovation on firm value. These results indicate that the effectiveness of green innovation in creating value for a company is conditional, materializing only when accompanied by environmental performance that is externally verified through PROPER.

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