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Green innovation and firm value: Evidence from Indonesian listed companies

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***Abstract*---**This study examines the effect of green innovation on firm value among publicly listed companies participating in the Corporate Performance Rating Program (PROPER) in Indonesia during the 2021–2024 period. Grounded in the Resource-Based View (RBV) theory, the study argues that green innovation constitutes a valuable strategic resource that enables firms to achieve sustainable competitive advantage while supporting long-term environmental sustainability. Specifically, green innovation is considered a unique organizational capability that is valuable, rare, difficult to imitate, and non-substitutable, thereby enhancing firm value. The sample was selected using purposive sampling, consisting of companies listed on the Indonesia Stock Exchange that consistently published financial and sustainability reports throughout the observation period, resulting in 228 firm-year observations. Panel data regression analysis was employed, and the Random Effect Model (REM) was selected as the most appropriate estimation method based on the Chow, Lagrange Multiplier, and Hausman tests. The findings reveal that green process innovation has a positive and significant effect on firm value, whereas green product innovation exhibits a positive but conditional effect. Specifically, green product innovation becomes statistically significant only when green process innovation is excluded from the regression model, indicating differences in the relative contribution of the two dimensions of green innovation to firm value. These findings support the Resource-Based View by demonstrating that internal operational capabilities embedded in green process innovation provide a stronger and more sustainable source of competitive advantage than green product innovation, which is relatively easier for competitors to observe and imitate. The study highlights the importance of prioritizing process-oriented environmental innovation as a strategic

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approach to enhancing firm value and sustaining long-term corporate competitiveness.

***Keywords*---**Firm value, green innovation, green process innovation, green product innovation, resource-based view.

Introduction

Firm value has become one of the primary indicators of corporate success because it reflects investors' perceptions of a firm's future growth, profitability, and long-term sustainability (Rahmantari, 2021). For publicly listed companies, firm value is closely associated with stock price movements and market confidence, as higher firm value increases investment attractiveness and enhances shareholders' wealth (Zhang et al., 2020). One of the most widely used proxies for measuring firm value is Tobin's Q, which compares a firm's market value with the replacement cost of its assets and captures investors' expectations regarding future corporate performance (Mediyanti et al., 2021; Su et al., 2020). Therefore, maintaining and improving firm value has become a strategic objective for companies operating in increasingly competitive and uncertain business environments (Linawati, 2022).

Despite the growing importance of firm value, companies are increasingly confronted with environmental challenges resulting from climate change, resource depletion, and stricter sustainability regulations. Indonesia, as one of the world's resource-rich countries, relies heavily on industries such as mining, manufacturing, and energy, which contribute significantly to economic growth but also generate considerable environmental impacts, including greenhouse gas emissions, water pollution, and excessive resource consumption (Afrida & Setyorini, 2024; Istiani & Amri, 2024). These challenges have shifted stakeholders' expectations, requiring companies not only to pursue financial performance but also to integrate environmental sustainability into their business strategies. Consequently, green innovation has emerged as a strategic approach through which firms develop environmentally friendly products, production processes, and technologies that reduce environmental impacts while improving operational efficiency (Rochmah, 2024).

The increasing importance of environmental innovation is also reflected in Indonesia's regulatory framework. Through the Corporate Performance Rating Program (PROPER), the Ministry of Environment and Forestry encourages companies to improve environmental management beyond minimum regulatory compliance, in accordance with the Regulation of the Minister of Environment No. 1 of 2021 and Law No. 32 of 2009 concerning Environmental Protection and Management. At the same time, Indonesia continues to expand the implementation of renewable energy, as demonstrated by the gradual increase in the realization of the national renewable energy mix between 2018 and 2023. Although these achievements remain below government targets, they indicate an increasing commitment toward sustainable industrial development. Nevertheless, despite these sustainability initiatives, the average Tobin's Q of publicly listed companies participating in PROPER declined continuously from 1.78 in 2021 to

1.61 in 2024, suggesting that market confidence has weakened despite the growing emphasis on environmental responsibility. This phenomenon raises an important question regarding whether green innovation has been sufficiently effective in enhancing firm value.

The relationship between green innovation and firm value can be explained through the Resource-Based View (RBV), which argues that sustainable competitive advantage originates from valuable, rare, inimitable, and non-substitutable organizational resources. Within this perspective, green innovation represents a strategic capability that enables firms to simultaneously improve environmental performance and create long-term economic value (Khanra et al., 2022). Green innovation is generally classified into two complementary dimensions: green product innovation and green process innovation (Chen et al., 2006; Xie et al., 2019). Green product innovation focuses on designing environmentally friendly products with lower environmental impacts throughout their life cycle, whereas green process innovation emphasizes improvements in production processes that minimize energy consumption, raw material usage, emissions, and waste generation (Husnaini & Tjahjadi, 2021). Both dimensions are expected to strengthen competitive advantage by improving operational efficiency, corporate reputation, and stakeholder trust (Su et al., 2020; Xie et al., 2019).

Although green innovation has received increasing scholarly attention, previous empirical findings remain inconclusive. Husnaini and Tjahjadi (2021) reported that green process innovation positively affects firm value, whereas green product innovation does not significantly influence firm value. Similarly, Xie et al. (2019) demonstrated that green process innovation improves corporate financial performance while simultaneously stimulating green product innovation. In contrast, Astuti and Ahmar (2025) found that neither green process innovation nor green product innovation significantly affects firm value. Comparable findings were reported by Rahelliamelinda and Handoko (2024) and Wijayanti (2024), who argued that many firms still perceive green innovation primarily as regulatory compliance rather than a strategic investment capable of creating market value. Conversely, Yuniarti and Soewarno (2022) and Cahyaningtyas et al. (2022) documented a positive relationship between green innovation and firm value, suggesting that environmentally responsible innovation enhances investors' perceptions and strengthens corporate competitiveness.

The inconsistencies in previous studies indicate the existence of several research gaps. First, empirical evidence regarding the relationship between green innovation and firm value remains inconclusive, with studies reporting positive, insignificant, and conditional effects. Second, previous studies have employed different measurement approaches for green innovation, including ISO 14001 certification, content analysis, innovation disclosure indices, and PROPER ratings, potentially contributing to inconsistent findings. Measurement approaches emphasizing environmental management systems may capture regulatory compliance rather than the firm's actual innovation capability, whereas content-based indicators better reflect tangible innovation outcomes. Third, relatively limited evidence simultaneously examines green process innovation and green product innovation as separate dimensions of green innovation within the

context of Indonesian publicly listed companies participating in PROPER during the post-pandemic recovery period.

This study addresses these gaps by distinguishing between green process innovation and green product innovation as two independent strategic capabilities and examining their respective effects on firm value among Indonesian listed companies participating in PROPER during 2021–2024. Unlike previous studies that generally treated green innovation as a single construct, this study investigates the relative contribution of each innovation dimension using panel data regression with the Random Effect Model (REM). By adopting the Resource-Based View as the theoretical foundation, this study extends the understanding of how different forms of environmental innovation contribute to firm value in an emerging market characterized by increasing sustainability regulations and growing stakeholder expectations. Therefore, this study aims to examine the influence of green process innovation and green product innovation on firm value while providing empirical evidence regarding the strategic role of green innovation in enhancing corporate competitiveness and long-term market value.

Literature Review and Hypothesis Development

Green process innovation refers to the adoption of environmentally friendly production technologies and operational processes that minimize environmental impacts while improving resource efficiency (Mukti & Priyawan, 2025). From the Resource-Based View (RBV), green process innovation represents a valuable strategic capability that enables firms to develop sustainable competitive advantages through efficient resource utilization, lower production costs, and enhanced environmental performance (Rizki & Hartanti, 2021). By improving energy efficiency, reducing waste generation, minimizing pollution, and optimizing the use of raw materials, firms can strengthen their reputation among stakeholders while simultaneously improving operational and financial performance. Consequently, these advantages are expected to increase investors' confidence and enhance firm value. Empirical evidence supports this argument, showing that green process innovation positively influences firm value by improving production efficiency and profitability (Ananda & Taqwa, 2024; Cahyaningtyas et al., 2022; Husnaini & Tjahjadi, 2021; Wang & Ahmad, 2024). Therefore, the following hypothesis is proposed:
H1: Green process innovation has a positive effect on firm value.

Green product innovation refers to the development of environmentally friendly products through the use of sustainable materials, efficient energy consumption, and product designs that facilitate recycling and reuse (Husnaini & Tjahjadi, 2021). According to the Resource-Based View (RBV), green product innovation constitutes a strategic resource that enables firms to create sustainable competitive advantages by offering differentiated products that are valuable, difficult to imitate, and aligned with growing environmental awareness. Environmentally friendly products not only reduce environmental costs but also enhance corporate reputation, strengthen stakeholder trust, and increase customer satisfaction, thereby improving firms' market competitiveness and long-term value. Previous studies consistently demonstrate that green product innovation positively contributes to firm value through enhanced profitability,

corporate reputation, and market valuation (Abbas & Umaroh, 2025; Cahyaningtyas et al., 2022; Fathoni et al., 2025). Accordingly, the following hypothesis is proposed:
H2: Green product innovation has a positive effect on firm value.

Methods

This study employed a quantitative research design using secondary data to examine the effect of green innovation on firm value among publicly listed companies participating in the Corporate Performance Rating Program (PROPER) in Indonesia during the 2021–2024 period. The population comprised all companies listed on the Indonesia Stock Exchange (IDX) that participated in PROPER, while the sample was selected using purposive sampling based on the following criteria: (1) companies consistently participating in PROPER during the observation period, (2) companies publishing complete annual reports and financial statements, and (3) companies disclosing sustainability reports or environmental information required to measure the research variables. Based on these criteria, 228 firm-year observations were obtained. Secondary data were collected from annual reports, sustainability reports, the Indonesia Stock Exchange (IDX), and the Ministry of Environment and Forestry (KLHK). Firm value was measured using Tobin's Q, while green innovation was examined through two dimensions: green process innovation and green product innovation, both measured using content analysis. Firm size, profitability, and leverage were included as control variables. Panel data regression analysis was conducted using Stata version 17. The Chow test, Hausman test, and Lagrange Multiplier test were performed to determine the most appropriate estimation model, and the Random Effect Model (REM) was selected for hypothesis testing.

Result and Discussion

Panel Data Model Selection
The appropriate panel data regression model was determined through the Chow, Hausman, and Lagrange Multiplier (LM) tests. As presented in Table 1, the Chow test produced significant probability values ($p < 0.001$) across all three models, indicating that the Fixed Effect Model (FEM) is preferred over the Common Effect Model (CEM).

Table 1. Chow Test Results

Effects Test	Model 1	Model 2	Model 3
Cross-section F	2.35 (0.0000)	2.23 (0.0000)	3.71 (0.0000)

Primary Data, 2026

The subsequent Hausman test generated probability values greater than 0.05 for all models, indicating that the Random Effect Model (REM) is statistically more appropriate than the Fixed Effect Model.

Table 2. Hausman Test Results

Test Summary	Model 1	Model 2	Model 3
Cross-section Random	7.28 (0.1163)	4.79 (0.3094)	5.01 (0.2866)

Primary Data, 2026

The LM test further confirmed that REM outperformed CEM, as all models produced significant Breusch–Pagan statistics ($p < 0.001$).

Table 3. Lagrange Multiplier Test Results

Breusch–Pagan	Model 1	Model 2	Model 3
Cross-section	16.66 (0.0000)	15.82 (0.0000)	50.55 (0.0000)

Primary Data, 2026

Based on these three specification tests, the Random Effect Model was selected as the final estimation model. Following Gujarati and Porter (2009), REM is estimated using Generalized Least Squares (GLS), which inherently accounts for heteroscedasticity and serial correlation through weighted estimation. Consequently, additional classical assumption tests were not required. Similar methodological approaches have been adopted by Ilham et al. (2022), Anjani et al. (2025), and Carolin and Susilawati (2024), who argue that GLS estimation provides efficient, consistent, and unbiased parameter estimates under the Random Effect framework.

Regression Results

The regression results for the three estimated models are presented in Table 4.

Table 4. Random Effect Regression Results

Variable	Model 1	Model 2	Model 3
GPI	4.052784 (6.92)***	4.282122 (7.73)***	-
GPDI	0.6006643 (1.29)	-	1.67293 (3.28)***
SIZE	0.0097272	0.0139164	0.145179
ROA	1.361704	1.306784	1.856012
DER	0.1829898	0.2008848	0.1421316

***$p < 0.01$

Primary Data, 2026

The Wald test demonstrates that all regression models are statistically significant, confirming that the explanatory variables jointly influence firm value.

Table 5. Wald Test Results

Wald Test	Model 1	Model 2	Model 3
Wald x^2	81.94	81.93	22.39
Prob > x^2	0.0000	0.0000	0.0002

Primary Data, 2026

The explanatory power of the regression models is summarized in Table 6.

Table 6. Coefficient of Determination (R^2)

R-squared	Model 1	Model 2	Model 3
Within	0.0891	0.0741	0.0383
Between	0.5562	0.5687	0.2285
Overall	0.3700	0.3708	0.1523

Primary Data, 2026

The overall R^2 values indicate that Models 1 and 2 explain approximately 37% of the variation in firm value, whereas Model 3 explains only 15.23%. Moreover, the substantially higher between R^2 values compared to within R^2 indicate that green innovation primarily explains cross-sectional differences among firms rather than year-to-year fluctuations. This finding is expected in panel data analyses because firm value is influenced by relatively stable firm characteristics rather than short-term temporal variations.

The Effect of Green Process Innovation on Firm Value

The regression results consistently demonstrate that Green Process Innovation (GPI) has a positive and statistically significant effect on firm value. As shown in Table 4, GPI remains significant both when estimated simultaneously with Green Product Innovation (Model 1: $\beta = 4.053$, $p < 0.001$) and when estimated independently (Model 2: $\beta = 4.282$, $p < 0.001$). The slightly higher coefficient observed in Model 2 suggests that the effect of GPI becomes stronger after excluding Green Product Innovation, indicating that process-oriented environmental innovation represents the dominant dimension of green innovation in explaining firm value.

These findings indicate that investors place greater emphasis on environmental innovations directly associated with firms' internal operational efficiency. The adoption of cleaner production technologies, energy-efficient manufacturing processes, waste reduction practices, and resource optimization not only lowers operational costs but also reduces environmental and regulatory risks (Li et al., 2023). Consequently, companies implementing green process innovation are perceived as possessing stronger long-term competitiveness and superior managerial capability, leading to higher market valuation.

The results strongly support the Resource-Based View (RBV), which argues that sustainable competitive advantage originates from valuable, rare, inimitable, and non-substitutable (VRIN) resources. Green process innovation represents an internally developed organizational capability involving technological knowledge, organizational learning, production expertise, and continuous process improvement that competitors cannot easily replicate (Gui et al., 2024). Because these capabilities are embedded within firms' operational systems, they create a more sustainable competitive advantage than externally observable innovations.

The present findings are consistent with Husnaini and Tjahjadi (2021), who reported that green process innovation enhances firm value through improvements in operational efficiency, lower resource consumption, and waste reduction. Likewise, Wang and Ahmad (2024) found that environmentally friendly production processes improve both environmental performance and market

valuation. Similar conclusions were reached by Ananda and Taqwa (2024), who demonstrated that process-oriented environmental innovation simultaneously improves cost efficiency and corporate reputation. Collectively, these findings confirm that green process innovation constitutes the most influential dimension of green innovation in enhancing firm value, as investors respond more strongly to operational capabilities that generate sustainable economic and environmental benefits than to product-related environmental initiatives alone.

The Effect of Green Product Innovation on Firm Value

The empirical findings regarding Green Product Innovation (GPDI) reveal a more nuanced relationship with firm value than Green Process Innovation. As presented in Table 4, GPDI does not significantly influence firm value when estimated simultaneously with Green Process Innovation in Model 1 ($\beta = 0.601$, $p = 0.199$). However, when Green Process Innovation is excluded from the regression model (Model 3), GPDI becomes positive and statistically significant ($\beta = 1.673$, $p = 0.001$). This pattern indicates that Green Product Innovation contributes positively to firm value, but its effect is conditional upon the presence of Green Process Innovation.

The contrasting results between Models 1 and 3 suggest the existence of a masking effect, whereby the stronger explanatory power of Green Process Innovation obscures the independent contribution of Green Product Innovation when both variables are included in the same regression model. This finding implies that environmentally friendly products create value for investors; however, their contribution becomes relatively less visible when firms simultaneously possess strong process-based environmental capabilities. In other words, investors appear to assign greater importance to operational improvements that directly enhance efficiency and reduce production costs than to environmentally friendly product characteristics alone.

From the perspective of the Resource-Based View (RBV), both Green Product Innovation and Green Process Innovation constitute strategic organizational resources capable of generating competitive advantage. Nevertheless, the nature of these capabilities differs substantially. Green Product Innovation primarily creates value through product differentiation, enhanced corporate reputation, and stronger customer preference for environmentally friendly products. In contrast, Green Process Innovation reflects internally embedded organizational capabilities involving production technology, operational knowledge, and continuous organizational learning, which are considerably more difficult for competitors to imitate (Gui et al., 2024). Consequently, process innovation provides a more sustainable competitive advantage because it directly improves operational efficiency while simultaneously strengthening environmental performance.

The findings indicate that Green Product Innovation remains an important strategic initiative because it enhances corporate reputation, strengthens stakeholder trust, and improves market differentiation through environmentally friendly products manufactured with recyclable materials, lower energy consumption, and sustainable product design (Husnaini & Tjahjadi, 2021). However, these benefits depend largely on consumers' purchasing behavior and investors' perceptions, making their impact on firm value relatively indirect

compared with the immediate operational benefits generated by process innovation. This explains why GPDI demonstrates a significant positive effect only when evaluated independently.

These findings are consistent with Fathoni et al. (2025), who reported that Green Product Innovation enhances firm value by creating product differentiation, expanding market opportunities, and improving profitability through environmentally friendly products. Similarly, Cahyaningtyas et al. (2022) argued that green product innovation strengthens corporate reputation and stakeholder confidence by reducing environmental impacts throughout the product life cycle, ultimately increasing market valuation. Abbas and Umaroh (2025) further demonstrated that environmentally friendly products serve as positive market signals, particularly for firms with relatively weak sustainability reputations, thereby improving investor confidence and firm value.

More importantly, the present findings strongly support those of Husnaini and Tjahjadi (2021), who distinguished between the operational pathway and the market perception pathway through which green innovation influences firm value. Their study concluded that Green Process Innovation exerts a stronger influence than Green Product Innovation when both dimensions are examined simultaneously. The current study confirms this argument by demonstrating that GPDI is statistically significant when evaluated independently but loses significance after controlling for Green Process Innovation. This finding suggests that process innovation constitutes the primary driver of firm value, whereas product innovation plays a complementary role by reinforcing the competitive advantages created through operational improvements.

Conclusion

This study examined the effect of green innovation on firm value among publicly listed companies participating in Indonesia's Corporate Performance Rating Program (PROPER) during the 2021–2024 period. The empirical findings demonstrate that green process innovation has a positive and significant effect on firm value, confirming that improvements in environmentally friendly production processes, energy efficiency, waste reduction, and resource optimization are positively valued by investors. These operational capabilities strengthen firms' competitive advantage and contribute to higher market valuation. In contrast, green product innovation exhibits a positive but conditional effect. Although environmentally friendly product development enhances firm value when evaluated independently, its effect becomes insignificant when green process innovation is simultaneously included in the regression model. This finding indicates that green process innovation exerts a more dominant influence on firm value than green product innovation.

The findings support the Resource-Based View (RBV), which argues that sustainable competitive advantage is derived from valuable, rare, inimitable, and non-substitutable resources. Green process innovation represents an internally embedded organizational capability that is difficult for competitors to replicate, thereby generating a stronger and more sustainable impact on firm value. Meanwhile, green product innovation primarily contributes through product

differentiation and corporate reputation, making its influence more dependent on market perception and consumer response. Overall, this study contributes to the green innovation literature by demonstrating that different dimensions of green innovation do not contribute equally to firm value. The evidence suggests that operational innovation constitutes the primary strategic driver of market value, whereas product innovation functions as a complementary capability that reinforces the benefits created through process innovation.

Managerial Implications

The findings provide important implications for corporate managers, investors, and policymakers seeking to enhance firm value through sustainability-oriented strategies. First, corporate managers should prioritize investments in green process innovation by adopting cleaner production technologies, improving energy efficiency, optimizing resource utilization, and reducing waste generation. Because investors respond more strongly to operational improvements that generate measurable economic and environmental benefits, firms should view green process innovation as a long-term strategic investment rather than merely a compliance requirement.

Second, green product innovation should be integrated with process innovation rather than implemented as a standalone sustainability initiative. Developing environmentally friendly products without strengthening environmentally efficient production systems may limit the overall contribution of green innovation to firm value. Therefore, firms should align product development strategies with internal operational improvements to maximize both environmental performance and market competitiveness.

Third, investors may consider green process innovation as a more reliable indicator of a firm's long-term competitiveness and sustainability performance. Compared with product-oriented environmental initiatives, process innovation reflects deeper organizational capabilities that are more difficult for competitors to imitate and more likely to generate sustainable financial returns.

Finally, policymakers and regulators, particularly the Ministry of Environment and Forestry and the Financial Services Authority (OJK), should encourage companies to strengthen substantive green innovation practices by promoting incentives for cleaner production technologies, resource-efficient operations, and environmentally sustainable manufacturing processes. Such policies may not only improve corporate environmental performance but also enhance firm value, thereby supporting Indonesia's transition toward sustainable economic development.

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