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THE IMPACT OF GREEN INNOVATION, RENEWABLE ENERGY, ENERGY CONSUMPTION ON FINANCIAL AND ENVIRONMENTAL PERFORMANCE

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Abstract

As global pressure for sustainability practices intensifies, many companies face a dilemma between pursuing profitability and fulfilling environmental responsibilities. This study differentiates between pollution prevention and control innovations and explores their impact on Return on Assets (ROA), market value (Tobin's Q), greenhouse gas (GHG) emissions, and the release of hazardous chemicals. The research aims to analyze the effects of green innovation, renewable energy use, and energy consumption levels on the financial and environmental performance of companies listed in the LQ45 index. A quantitative approach using panel data regression analysis is employed. The results indicate that green innovation has a positive and significant effect on financial performance but paradoxically increases environmental burdens due to its still reactive approach. Renewable energy has not yet had a significant financial impact, although it has begun to reduce chemical emissions. Energy consumption correlates positively with financial performance, reflecting suboptimal energy efficiency. These findings highlight the need for more proactive green strategies and efficient integration of renewable energy to achieve long-term sustainability.

Keywords: Green innovation; Renewable energy; Energy consumption; Financial performance, Environmental performance.

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INTRODUCTION

Climate change has become one of the most critical global challenges in recent decades, marked by rising global temperatures, increasing frequency of extreme weather events, and the degradation of environmental quality (Basuki, 2025; Cheng et al., 2024; Septiani & Hernawati, 2024). This condition has prompted various stakeholders, including governments, academics, and the business sector, to adopt a sustainable development paradigm (Siemieniako et al., 2024; van der Borgh et al., 2024). In this context, companies are no longer solely oriented toward achieving financial performance but are also required to consider the environmental impact of their operations. As a result, sustainability has become an integral part of modern business strategy (Dhakal, 2026; Poberezhna et al., 2025).

In addressing these demands, companies are often faced with a dilemma between achieving profitability and fulfilling environmental responsibility. On the one hand, companies are required to enhance operational efficiency, market value, and returns on investment to meet shareholders' expectations. On the other hand, they must allocate resources to reduce environmental impacts through emission control, energy efficiency, and the adoption of sustainable business practices (H. Li, 2022; Rathi et al., 2022). This dilemma reflects a trade-off between short-term economic goals and long-term sustainability, particularly because investments in environmentally friendly practices generally require substantial initial costs. Therefore, a strategic approach is needed to integrate these two objectives simultaneously (L. Liu et al., 2024; Ma, 2025; Umair Anwar et al., 2025).

One approach that has gained increasing attention is the implementation of green innovation. Green innovation refers to the development of products, processes, and technologies that reduce negative environmental impacts while improving resource efficiency. From an economic perspective, green innovation has the potential to create competitive advantages through cost efficiency, enhanced corporate reputation, and access to broader markets (M. Liu & Liu, 2024; Zeng & L, 2020). In addition, the use of renewable energy has become an important strategy to reduce dependence on fossil-based energy, which significantly contributes to greenhouse gas emissions. Meanwhile, efficient management of energy consumption plays a crucial role in reducing operational costs and minimizing environmental pressure. Thus, these three aspects are key components in supporting sustainable corporate performance (Akyüz & Coşgun, 2023; Awamleh et al., 2025).

In the Indonesian context, the phenomenon of green innovation implementation is increasingly evident, particularly among large companies listed in the LQ45 index. This index represents firms with high liquidity and market capitalization, which are expected to bear greater responsibility for sustainability issues. In recent years, these companies have improved transparency through the publication of sustainability reports containing information on environmental management, such as the reduction of greenhouse gas (GHG) emissions, energy efficiency, and the use of renewable energy. This indicates a growing awareness among companies of the importance of sustainable business practices.

This phenomenon is also reflected in the empirical data of LQ45 companies during the 2019–2023 research period.

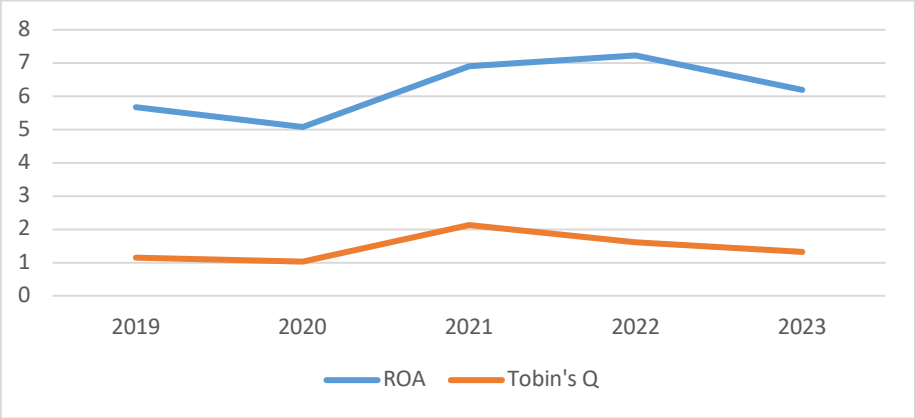

Figure 1. Financial Performance LQ45

The financial performance measured through Return on Assets (ROA) and Tobin's Q shows a relatively stable and upward trend from year to year. This indicates that the company is able to maintain and even improve its profitability and market value despite increasing pressure related to sustainability practices. However, on the other hand, environmental performance measured through greenhouse gas (GHG) emissions and chemical releases still shows a fluctuating and relatively high trend. This condition suggests that the company's increased activity and performance have not yet been fully balanced by improvements in environmental performance.

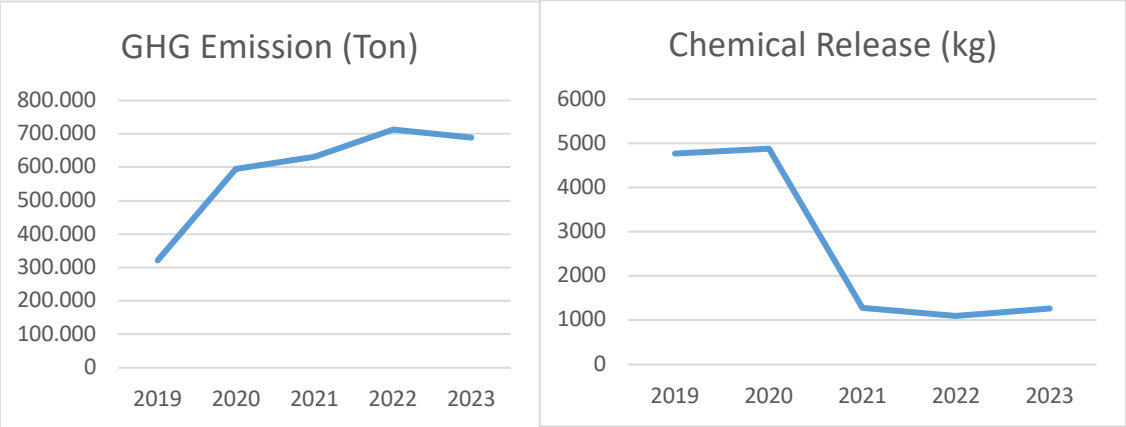

Figure 2. Enviromental Performance

The graph shows that the environmental performance of LQ45 companies remains inconsistent throughout the observation period. On the one hand, greenhouse gas (GHG) emissions tend to increase year by year, indicating that the companies' operational activities continue to contribute to rising carbon emissions. On the other hand, chemical releases show a fairly significant downward trend, although there was a slight increase in the most recent period. These findings suggest that efforts to improve environmental performance have begun to emerge, but they are still partial and have not yet consistently addressed all aspects of environmental impact. However, this condition indicates a clear gap between the ideal expectation and the actual reality. Ideally, companies are expected to achieve a balance between financial performance and environmental sustainability. However, the empirical evidence shows that while financial performance continues to

improve, environmental performance remains inconsistent and tends to deteriorate. This imbalance reflects that sustainability practices have not yet been optimally implemented (Arlie et al., 2025; Belgacem & Louhichi, 2026).

In response to these challenges, companies have started adopting various sustainability strategies, such as implementing green innovation, utilizing renewable energy, and managing energy consumption. Green innovation is expected to reduce environmental impact through improvements in production processes and the use of more environmentally friendly technologies. Meanwhile, the use of renewable energy serves as an alternative to reduce dependence on fossil-based energy, and efficient energy consumption plays an important role in lowering operational costs while also reducing emissions (Javed et al., 2024; Kafait et al., 2025; Song & Ma, 2022). However, in practice, the implementation of these three strategies has not yet been fully optimal. Many companies still tend to adopt reactive approaches, such as pollution control, rather than preventive strategies that can reduce environmental impact from the early stages of the production process. In addition, the use of renewable energy remains limited, while high energy consumption continues to be a key characteristic of companies, especially in energy-intensive sectors (Hariadi et al., 2023).

Research on the relationship between green innovation, renewable energy, and energy consumption and firm performance shows mixed results. Several studies report a positive effect, where green innovation has been proven to improve both financial and environmental performance (Lee et al., 2023; M. Liu & Liu, 2024; D. Zhang, 2022; X. Zhang et al., 2024) . In addition, the use of renewable energy also contributes to enhancing firm performance and sustainability (Sitompul et al., 2024). However, inconsistent findings have also been identified. Qiang and Yang (2023) argue that the relationship between green innovation and firm performance remains inconclusive, mainly due to differences in context and the high initial implementation costs. Meanwhile, energy consumption can have a positive impact if managed efficiently, but it may reduce environmental performance if not properly controlled (Yang, 2025).

Most existing studies, however, are conducted in developed countries and tend to examine these variables separately (Lee et al., 2023; M. Liu & Liu, 2024; Sitompul et al., 2024; D. Zhang, 2022; X. Zhang et al., 2024). Therefore, the research gap of this study lies in the limited number of studies that simultaneously integrate green innovation, renewable energy, and energy consumption, particularly in the context of developing countries such as Indonesia. This study offers several novelties compared to prior research. First, this study simultaneously integrates green innovation, renewable energy, and energy consumption within a single research model, whereas most previous studies tend to examine these variables separately. Second, this study not only focuses on financial performance but also incorporates environmental performance, providing a more comprehensive perspective on corporate sustainability. Third, this study specifically examines companies in a developing country context, particularly Indonesia, which has different regulatory environments and sustainability challenges compared to developed countries.

Based on the background and identified research gap, this study aims to analyze the impact of green innovation, renewable energy, and energy consumption on both financial and environmental performance of companies listed in the LQ45 index. This study is expected to provide empirical contributions to the literature on corporate sustainability in developing countries, particularly Indonesia, as well as offer practical implications for companies in formulating strategies that balance profitability and environmental responsibility.

LITERATURE REVIEW

Resource-Based View (RBV)

The Resource-Based View (RBV) was first introduced by Edith Penrose (1959) and later developed by Jay Barney (1991). RBV states that a firm's competitive advantage is determined by its ability to effectively manage and utilize its resources, particularly those that are valuable, rare, inimitable, and non-substitutable. From this perspective, a firm is viewed as a bundle of strategic resources that can be leveraged to achieve superior performance.

Building on the Resource-Based View (RBV), the relationships among green innovation, renewable energy, and energy consumption with firm performance can be understood as the firm's strategic capability in managing its resources. Green innovation reflects an intangible capability that enables firms to develop environmentally friendly processes and technologies, while renewable energy represents a transformation of energy resources toward more sustainable inputs. At the same time, energy consumption reflects how efficiently firms utilize their operational resources. When these three aspects are managed effectively, they form a complementary bundle of strategic resources that can enhance both financial and environmental performance. Conversely, inefficient energy use or suboptimal implementation of green innovation may weaken the firm's ability to achieve competitive advantage. Therefore, RBV suggests that firm performance is not determined by a single factor, but by how well firms integrate and optimize these sustainability-oriented resources into their overall strategy (Cîrt et al., 2026; Marouani, 2024; Shekhawat et al., 2025).

Porter Hypothesis

The Porter Hypothesis was proposed by Michael E. Porter and Claas van der Linde (1995), which argues that environmental regulatory pressure can encourage firms to innovate, ultimately improving efficiency and competitiveness. This theory emphasizes that environmentally driven innovation is not merely a cost burden but can generate economic benefits through increased productivity and more efficient resource use.

In this study, the Porter Hypothesis is used to explain that the implementation of green innovation is not only aimed at complying with environmental regulations or pressures but can also enhance firm performance. Environmentally friendly innovation enables firms to reduce energy waste, improve production efficiency, and develop more competitive products in the market. This leads to improved financial performance through cost efficiency and increased firm value. In addition, such innovation contributes to better environmental performance by reducing emissions and minimizing negative environmental impacts. Therefore, green innovation can provide dual benefits for firms, both economically and environmentally.

Green Innovation and Financial Performance

Based on the Resource-Based View (RBV), green innovation is considered a strategic capability that can enhance efficiency and create a sustainable competitive advantage. Firms that successfully implement green innovation tend to adopt environmentally friendly technologies, including the use of renewable energy sources. The adoption of renewable energy contributes to reducing dependence on non-renewable energy and leads to more efficient energy consumption.

Furthermore, improved energy efficiency and the use of cleaner energy sources can significantly reduce emissions and environmental impact, thereby enhancing environmental performance. In turn, better environmental performance can strengthen a firm's reputation, attract environmentally conscious investors, and reduce regulatory risks, which ultimately leads to improved financial performance. Previous studies also indicate that green innovation has a direct and indirect positive effect on financial performance through these mechanisms (Awamleh et al., 2025; L. Liu et al., 2024; Qing et al., 2022; C. Zhang et al., 2025).
H_1: Green innovation has a positive effect on financial performance.

Green Innovation and Environmental Performance

Based on the Resource-Based View (RBV) and the Porter Hypothesis, green innovation is considered a strategic capability that enables firms to reduce environmental impact through cleaner production processes and more efficient resource utilization. Specifically, the implementation of green innovation encourages firms to adopt eco-friendly technologies, optimize energy use, and shift toward less polluting inputs, including renewable energy sources. These practices contribute to lowering emissions, reducing waste generation, and minimizing the overall environmental footprint of business operations.

As a result, firms are able to improve their environmental performance by achieving higher levels of environmental efficiency and compliance with environmental regulations. In addition, better environmental performance may also reflect a firm’s commitment to sustainability, which enhances its legitimacy and long-term viability. Previous studies consistently show that green innovation has a positive and significant effect on environmental performance (Rahmani et al., 2024).
H_2: Green innovation has a positive effect on environmental performance.

Renewable Energy and Financial Performance

Based on the Resource-Based View (RBV), the adoption of renewable energy can be viewed as a strategic resource that supports long-term efficiency and competitiveness. The use of renewable energy enables firms to reduce dependence on fossil fuels, stabilize energy costs, and improve energy efficiency over time. Although the initial investment in renewable energy infrastructure is relatively high, it can lead to cost savings in the long run through lower operational and energy expenses.

Furthermore, the adoption of renewable energy can enhance a firm’s environmental performance by reducing carbon emissions and environmental impact, which in turn strengthens corporate reputation and stakeholder trust. These improvements may positively influence financial performance through increased market value and investor confidence. However, previous studies show mixed results regarding its impact on financial performance, as the benefits often depend on factors such as investment scale,

regulatory support, and the time horizon required to realize returns (Dorigoni & Anzalone, 2024).
H_3: Renewable energy has an effect on financial performance.

Renewable Energy and Environmental Performance

Based on the Porter Hypothesis, the use of renewable energy reflects an environmentally driven strategy that can improve environmental outcomes. The adoption of renewable energy encourages firms to shift away from fossil fuel-based energy sources toward cleaner alternatives, thereby reducing carbon emissions, air pollution, and overall environmental degradation. In addition, renewable energy usage often promotes more efficient energy management and supports sustainable production processes.

Through these mechanisms, firms can significantly enhance their environmental performance by lowering their environmental footprint and complying with increasingly stringent environmental regulations. Improved environmental performance also signals a firm's commitment to sustainability, which strengthens its legitimacy among stakeholders. Previous studies generally find that renewable energy has a positive and significant impact on environmental performance (Achuo et al., 2022).
H_4: Renewable energy has a positive effect on environmental performance.

Energy Consumption and Financial Performance

From an economic perspective, energy consumption is closely related to production activities and operational scale. Higher energy consumption often reflects increased production capacity and business expansion, which may lead to higher output and revenue generation. In this context, energy consumption can positively contribute to financial performance, particularly when it supports productive and value-creating activities.

However, the impact of energy consumption on financial performance also depends on the efficiency of energy use. Excessive or inefficient energy consumption may increase operational costs and reduce profitability. Therefore, firms that are able to manage and optimize their energy consumption are more likely to achieve better financial performance. Previous studies indicate that the relationship between energy consumption and firm performance can be positive, but it is often influenced by energy efficiency and cost management (Fortea et al., 2024; Özmerdivanlı & Sönmez, 2025).
H_5: Energy consumption has a positive effect on financial performance**.**

Energy Consumption and Environmental Performance

From an environmental perspective, high energy consumption, particularly when it relies on non-renewable energy sources, contributes significantly to increased carbon emissions and environmental degradation. The intensive use of fossil fuels leads to higher levels of greenhouse gas emissions, air pollution, and resource depletion, which negatively affect environmental quality.

Furthermore, without efficient energy management and the adoption of cleaner energy alternatives, excessive energy consumption increases environmental pressure and accelerates ecological damage. As a result, firms with higher and inefficient energy consumption tend to exhibit lower environmental performance. Previous studies consistently demonstrate a negative relationship between energy consumption and environmental performance (Gibba et al., n.d.; Idroes et al., 2024).
H_6: Energy consumption has a negative effect on environmental performance**.**

RESEARCH METHOD

This study uses a quantitative method with an explanatory research approach, which aims to explain the causal relationship between variables (Creswell, 2018). The analysis was conducted using descriptive and inferential statistics to describe the characteristics of the data (Sekaran & Bougie, 2016). The population in this study includes companies listed on the LQ45 index. The sample selection uses non-probability sampling through purposive sampling. Purposive sampling is a technique that selects samples based on specific criteria. The criteria used to select samples are 1) companies that have financial reports and sustainability reports consecutively on the IDX during 2019-2023. 2) Companies that have consistently demonstrated values related to innovation prevention and control, resulting in 20 companies from 2019 to 2023. This sample selection is based on the increasing global attention to sustainable business practices and the demand for companies to not only pursue profitability but also consider social and environmental impacts. This refers to the reporting of financial statements and sustainability reports by companies. In analyzing the relationship between variables, this study uses panel data regression, which allows for simultaneous analysis of cross-time and cross-company data to enhance the validity of the results. With this approach, the study can provide more comprehensive findings regarding the factors that influence the financial and environmental performance of companies included in the LQ45 index. The following is the equation:

$ROA_{it} = \alpha + \beta_1 PCP_{it} + \beta_2 RE_{it} + \beta_3 EC_{it} + e_{it}$ ……..1)
$Tobins\ Q_{it} = \alpha + \beta_1 PCP_{it} + \beta_2 RE_{it} + \beta_3 EC_{it} + e_{it}$ ……..2)
$Emisi_{it} = \alpha + \beta_1 PCP_{it} + \beta_2 RE_{it} + \beta_3 EC_{it} + e_{it}$ ……..3)
$Chemical_{it} = \alpha + \beta_1 PCP_{it} + \beta_2 RE_{it} + \beta_3 EC_{it} + e_{it}$ ……..4)

Keterangan:
ROA = Return on Assets.
PCP = Prevention & Control Pollution.
RE = Renewable Energy.
EC = Energy Consumption.
i = Firm i.
t = year at-.

RESEARCH RESULTS

Based on the results of data analysis, the following research results were obtained:

Table 1. Panel Analysis Result

Variable	ROA		TOBINS Q		GHG Emission		Chemical Release	
	Coefficient	Prob	Coefficient	Prob	Coefficient	Prob	Coefficient	Prob
Inovasi Hijau	95.133	0.0149	251.9	0.0594	202.103	0.0258	2.783	0.0065
Renewable Energy	1.28E-05	0.5569	-0.00001	0.0284	0.0001	0.0701	-1.94	0.0552
Energy Consumption	3.05E-08	0.0174	1.07E-07	0.0172	4.60E-01	0.0000	3.344	0.0012

Based on the table 1 above, the results of this study reveal a complex relationship between green innovation, renewable energy, energy consumption, and their impact on financial and environmental performance. The following is a description of the findings in the form of analytical paragraphs.

The Impact of Green Innovation on Financial Performance

The impact of green innovation on financial performance shows positive and significant results. Based on the ROA indicator, a coefficient of 95.133 with a probability value of 0.0149 indicates that green innovation has a significant impact on improving company profitability. Meanwhile, based on the Tobin's Q indicator, a coefficient of 251.9 with a probability value of 0.0594 shows a positive effect that is close to significant at the 10% level. This means that green innovation also has the potential to increase the company's market value, although its strength is not as strong as that of ROA.

The Impact of Green Innovation on Environmental Performance

The impact of green innovation on environmental performance, based on regression results, actually shows a direction that is not in line with expectations. In the GHG Emission indicator, the coefficient is 202.103 with a probability value of 0.0258, and in the Chemical Release indicator with a coefficient of 2.783 and a probability of 0.0065, both show significant but positive results. This indicates that higher levels of green innovation are actually accompanied by increased greenhouse gas emissions and chemical waste. This phenomenon may occur because the innovations implemented are still in their early stages or have not yet fully optimized their efficiency in reducing environmental impacts.

The Impact of Renewable Energy on Financial Performance

The impact of renewable energy on financial performance yields mixed findings. In terms of ROA, the coefficient is very small at 1.28E-05 and insignificant (probability 0.5569), indicating that the use of renewable energy has no significant effect on company profitability. However, in Tobin's Q indicator, the negative coefficient of -0.00001 with a probability of 0.0284 indicates a significant negative effect on the company's market value. This may occur because investments in renewable energy may be considered expensive or have not yet provided short-term benefits from an investor's perspective.

The Impact of Renewable Energy on Environmental Performance

The impact of renewable energy on environmental performance is beginning to show more positive results. Although the GHG Emission indicator has a positive coefficient of 0.0001 with a probability of 0.0701 (approaching significance at the 10% level), this result is still acceptable as an indication that the transition to renewable energy is not yet optimal in reducing emissions. Meanwhile, on the Chemical Release indicator, the negative coefficient of -1.94 with a probability of 0.0552 indicates that the use of renewable energy contributes to reducing chemical waste, and this is significant at the 10% level. This means that renewable energy has the potential to help improve a company's environmental performance, particularly in reducing chemical pollution.

The Effect of Energy Consumption on Financial Performance

The effect of energy consumption on financial performance shows strong and positive results. The coefficient for ROA is 3.05E-08 with a probability of 0.0174, and for Tobin's Q it is 1.07E-07 with a probability of 0.0172, both of which are significant. This indicates that an increase in energy consumption is positively correlated with the profitability and market value of a company. In other words, the higher the energy consumption, the greater the company's activity and productivity, which positively impacts its financial performance.

The Impact of Energy Consumption on Environmental Performance

The impact of energy consumption on environmental performance shows a significant negative effect. In the GHG Emission indicator, the coefficient is 0.460 with a probability of 0.0000, and in the Chemical Release indicator, it is 3.344 with a probability of 0.0012. Both indicate that high energy consumption directly increases greenhouse gas emissions and chemical waste. This reinforces the view that high energy consumption, especially from non-renewable energy sources, has a detrimental impact on environmental quality.

DISCUSSION

The Effect of Green Innovation on Financial Performance

The results of this study indicate that green innovation has a positive effect on corporate financial performance, particularly in terms of profitability and firm value. This finding suggests that firms that intensify their green innovation practices are able to improve operational efficiency and generate higher economic returns. In addition, the positive tendency observed in market-based performance reflects that investors increasingly perceive environmentally responsible firms as more valuable and sustainable in the long term (J. Li et al., 2024).

This result can be explained through the efficiency and value-creation mechanisms embedded in green innovation. The implementation of environmentally friendly technologies, process optimization, and efficient resource utilization enables firms to reduce waste, minimize energy consumption, and lower environmental-related costs. As a result, firms can enhance productivity without increasing operational risks, particularly those associated with environmental regulations. Moreover, green innovation strengthens corporate reputation and signals a strong commitment to sustainability, which in turn increases stakeholder trust and investor confidence. These conditions are highly relevant to the growing global emphasis on sustainable business practices, as highlighted in the introduction (Basuki, 2025).

From a theoretical perspective, this finding is consistent with the Resource-Based View (RBV), which emphasizes that firms can achieve competitive advantage through the effective use of valuable and inimitable resources. In this context, green innovation serves as a strategic capability that enhances efficiency while simultaneously reducing environmental costs. Furthermore, this result also supports the Porter Hypothesis, which suggests that environmental innovation can generate both economic and environmental benefits through efficiency improvements and innovation-driven competitiveness.

This finding is consistent with several recent studies. For instance, Cheng et al., (2024) find that green innovation improves financial performance through cost efficiency and enhanced innovation capability. Similarly, M. Liu & Liu, (2024) show that

environmentally oriented innovation strengthens firm value by improving market competitiveness and investor perception. In addition, Zhang et al., (2025)demonstrate that green innovation contributes to profitability by reducing environmental costs and improving operational efficiency.

Furthermore, Zhang et al., (2024) highlight that environmentally responsible strategies enhance financial outcomes through better risk management and stakeholder trust. (L. Liu, 2024) also confirm that sustainability-oriented innovation improves firm performance by strengthening corporate reputation.

The Impact of Green Innovation on Environmental Performance

In contrast to its positive effect on financial performance, green innovation in this study exhibits a paradoxical relationship with environmental performance. The findings indicate that green innovation is positively associated with greenhouse gas (GHG) emissions and chemical releases, suggesting that an increase in green innovation activities is accompanied by higher environmental burdens.

This counterintuitive result may be explained by the transitional and implementation-related effects of green innovation. In the early stages, firms often require substantial investments in new technologies, increased energy use, and adjustments in production processes. These activities may temporarily lead to higher emissions and environmental pressures before the efficiency benefits of green innovation are fully realized. Moreover, firms that actively engage in green innovation are often large-scale or high-production firms, which inherently generate higher emissions despite improvements in efficiency.

From the perspective of the Resource-Based View, green innovation remains a strategic capability that enhances competitiveness and operational efficiency. However, its environmental benefits may not be immediate and are more likely to materialize in the long term as firms optimize resource utilization and production systems. Similarly, while the Porter Hypothesis suggests that environmental innovation can generate both economic and environmental benefits, this study indicates that such benefits are conditional and may depend on the stage of implementation and the effectiveness of environmental management practices.

These findings are not entirely inconsistent with prior studies. The study Kafait et al., (2025) empirically demonstrates that the relationship between green innovation and environmental performance follows a non-linear (U-shaped) pattern, in which green innovation initially increases environmental pressure before eventually reducing it after a certain threshold is reached. This result is further supported by Rahmani et al., (2024), which reveals that empirical findings on the relationship between green innovation and environmental performance remain inconsistent, with some studies even reporting negative impacts in the short term.

Furthermore, prior research explains that this phenomenon is driven by a transitional effect during the implementation of green innovation. In the early stages, firms are required to undertake substantial investments in new technologies, increase energy consumption, and adjust production systems that are not yet fully efficient. These conditions may lead to higher emissions before efficiency gains can be realized. In addition, the study Batool & Mohsin, (2025) emphasizes that the impact of green innovation on environmental performance is highly contingent upon governance and

policy factors. Without adequate institutional and managerial support, green innovation does not necessarily lead to immediate environmental improvements.

The Effect of Renewable Energy on Financial Performance

This study finds that renewable energy does not have a significant effect on accounting-based performance, while it has a negative impact on market-based performance. This suggests that although renewable energy adoption does not directly influence short-term profitability, it may negatively affect how investors perceive firm value. In particular, the negative market response indicates that firms investing in renewable energy are often undervalued by the capital market.

This phenomenon can be explained by the high initial investment and uncertainty associated with renewable energy projects. The adoption of renewable energy technologies, such as solar panels, bioenergy systems, and other clean energy infrastructure, requires substantial capital expenditure. In the short term, these investments increase operational costs and reduce financial flexibility, while the economic benefits are not immediately observable. As a result, investors may perceive such investments as a financial burden rather than a value-creating strategy.

From a theoretical perspective, this finding reflects the trade-off between short-term costs and long-term benefits in sustainability investment. The Porter Hypothesis suggests that environmental strategies can enhance competitiveness; however, this study indicates that the benefits of renewable energy adoption are not instant and depend on the firm's ability to manage investment efficiency and time horizon.

This result is consistent with Sitompul et al., (2024), who argue that renewable energy transitions require substantial capital expenditure that may reduce firm attractiveness in the short term. However, it contrasts with Dorigoni and Anzalone (2024), who find that renewable energy can improve firm value in the long run. This suggests that the impact of renewable energy on financial performance is time-dependent, where short-term market reactions may differ from long-term economic benefits.

L. Li et al., (2024) also finds that renewable energy-related firms tend to underperform in the stock market due to climate-related risks and policy uncertainty. Similarly, Suyadal & Gül, (2024) reports negative abnormal returns, indicating that investors often perceive renewable energy investments as a financial burden rather than a value-enhancing strategy. In addition, Mirza et al., (2026) highlights the existence of a "green paradox," where sustainability-oriented investments may weaken financial performance in the short term due to high costs and delayed returns.

The Effect of Renewable Energy on Environmental Performance

In the environmental performance dimension, renewable energy shows a generally positive but inconsistent effect. The findings suggest that while the impact on greenhouse gas (GHG) emissions is not yet significant, renewable energy adoption contributes to a reduction in chemical releases, indicating its potential to improve certain aspects of environmental quality. This implies that the environmental benefits of renewable energy may emerge gradually and may not be uniformly reflected across all environmental indicators.

This phenomenon can be explained by the varying nature of renewable energy implementation. Different types of renewable energy sources, such as solar, biomass, or biofuels, have distinct environmental impacts depending on their production processes, technological efficiency, and integration into existing energy systems. As a result, the effectiveness of renewable energy in reducing emissions and pollution is highly dependent on the scale of adoption, technological maturity, and the structure of the firm's energy consumption.

Furthermore, the partial impact observed in this study suggests that the transition to renewable energy is still in progress, where firms have not yet fully optimized the environmental benefits of clean energy utilization. Over time, as renewable energy technologies become more efficient and widely adopted, their contribution to environmental performance is expected to become more consistent and significant.

This finding is consistent with Dopierała et al. (2022) who emphasize that renewable energy plays an important role in improving corporate environmental sustainability, although its impact may vary depending on implementation conditions. Idroes et al., (2024) finds that the effect of renewable energy on environmental quality is not always significant and varies depending on economic and energy conditions. Similarly, Wang et al., (2024) demonstrates that renewable energy can reduce emissions; however, its effectiveness depends heavily on technological efficiency and implementation processes. Furthermore, Yildiz, (2024) shows that renewable energy firms tend to exhibit better environmental performance, although the outcomes are not consistent across firms and contexts.

As a result, the effectiveness of renewable energy in reducing emissions and pollution is highly dependent on the scale of adoption, technological readiness, and the firm's energy consumption structure. This argument is further supported by Satrianto et al., (2024), which highlights that the environmental benefits of renewable energy are conditional upon structural and developmental factors.

Moreover, the partial impact observed in this study suggests that the transition toward renewable energy is still ongoing, and firms have not yet fully optimized the environmental benefits of clean energy utilization. This aligns with the findings of Rastegar et al., (2024), which emphasizes that the effectiveness of renewable energy is strongly influenced by policy support and implementation strategies. Without adequate institutional support and technological optimization, the environmental contribution of renewable energy may remain limited in the short term.

The Effect of Energy Consumption on Financial Performance

This study finds that energy consumption has a positive effect on financial performance, indicating that firms with higher energy usage tend to achieve better profitability and firm value. This relationship reflects the role of energy as a key input in production activities, particularly in capital- and energy-intensive industries. In this context, higher energy consumption is often associated with greater production capacity, increased asset utilization, and business expansion.

This phenomenon can be explained by the close link between energy consumption and productive activities. Firms operating at a larger scale require substantial energy inputs to sustain production processes, and therefore, higher energy consumption often signals higher output and revenue generation. In addition, stable and sufficient energy use may

indicate operational reliability, which supports continuous production and financial performance.

However, this positive relationship should be interpreted with caution. High energy consumption may also reflect inefficiency if it is not accompanied by effective energy management practices. Without improvements in energy efficiency, increased energy use can lead to higher operational costs and expose firms to risks associated with energy price volatility and regulatory changes. This suggests that while energy consumption contributes to short-term financial performance, its long-term impact depends on how efficiently energy resources are managed.

This finding is consistent with Cheng et al. (2024) who emphasize the importance of integrating energy efficiency strategies to balance operational performance and sustainability pressures. From a theoretical perspective, this result also aligns with the Environmental Kuznets Curve, which suggests that economic growth in its early stages is often accompanied by increased resource consumption before efficiency improvements are realized (Septiani & Hernawati, 2024).

In other side similarly with Meutia & Kartasari, (2023) finds that higher energy consumption is positively associated with firm productivity and profitability, as energy supports production efficiency and operational scale. Similarly, Sitompul et al., (2024) reports that firms with greater energy consumption tend to generate higher revenues due to increased production output. These studies reinforce the argument that energy consumption plays a vital role in supporting firm performance, particularly in industries that rely heavily on continuous production processes.

However, this positive relationship should be interpreted with caution. High energy consumption may also reflect inefficiency if it is not accompanied by effective energy management practices. Without improvements in energy efficiency, increased energy use can lead to higher operational costs and expose firms to risks associated with energy price volatility and regulatory pressures. This argument is supported by Qalati et al., (2023), which emphasizes that excessive energy consumption without efficiency improvements may reduce long-term profitability. Therefore, the benefits of energy consumption are conditional upon how efficiently firms utilize energy resources.

The Effect of Energy Consumption on Environmental Performance

From an environmental perspective, energy consumption has a significant negative effect on environmental performance. Higher levels of energy use are associated with increased greenhouse gas (GHG) emissions and chemical releases, indicating that greater energy consumption leads to higher environmental pollution. This result can be explained by the continued reliance of firms on fossil-based energy sources, such as coal and natural gas. As production activities expand, energy consumption increases accordingly, and when this energy is derived from non-renewable sources, it directly contributes to carbon emissions and environmental degradation. In addition, the relatively low level of energy efficiency further exacerbates this issue, as firms continue to rely on energy-intensive technologies without adequate energy management systems.

From a theoretical perspective, this finding aligns with the Environmental Kuznets Curve, which suggests that in the early stages of economic growth, increased production is often accompanied by rising environmental degradation. In the context of emerging economies, this effect is amplified by the dominance of fossil energy in the energy mix. This finding is also supported by Ansari et al., who highlight that non-renewable energy consumption is a major contributor to environmental degradation.

Therefore, without effective energy management strategies such as improving energy efficiency, diversifying energy sources, and adopting cleaner technologies high energy consumption will continue to hinder environmental performance. Moreover, increasing regulatory pressure and stakeholder awareness regarding sustainability further reinforce the need for firms to transition toward more environmentally responsible energy practices.

These findings are consistent with prior empirical studies. For instance, Georgescu, (2023) demonstrates that increased energy consumption is closely linked to higher carbon emissions, especially in economies with high energy dependence. Similarly, J. Li et al., (2023) finds that energy-intensive economic activities significantly contribute to environmental degradation through rising CO_2 emissions. In addition, Stamatiou, (2023) provides evidence that electricity consumption has a positive and significant impact on carbon emissions, supporting the argument that energy use directly exacerbates environmental pressure.

As production activities expand, energy consumption increases accordingly, and when this energy is derived from non-renewable sources, it directly contributes to carbon emissions and environmental pollution. This argument is further supported by Keung et al.,(2023) which highlights that low-quality (fossil-based) energy consumption significantly increases emissions, whereas cleaner energy sources can mitigate environmental damage.

CONCLUSION

Based on the results, green innovation has a positive impact on financial performance, but shows a paradoxical effect on environmental performance, as it is associated with increased environmental burden. Renewable energy does not significantly improve financial performance and is perceived negatively by the market due to high initial costs, although it begins to contribute to reducing environmental pollution. Meanwhile, energy consumption improves financial performance by supporting production activities, but at the same time worsens environmental performance due to high reliance on fossil energy. Overall, firms face a trade-off between short-term financial gains and long-term environmental sustainability. From a managerial perspective, firms need to balance growth and sustainability by improving energy efficiency, adopting renewable energy gradually, and implementing more preventive green innovation strategies. Theoretically, these findings support the Resource-Based View and the Environmental Kuznets Curve, showing that the benefits of sustainability strategies are often not immediate and may involve short-term trade-offs. This study is limited to LQ45 firms and quantitative data, which may not fully capture implementation complexity. Future research is suggested to include additional variables such as environmental governance or green HRM and to use mixed methods for deeper insights**.**

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