Al Qodiri: Jurnal Pendidikan, Sosial dan Keagamaan
Volume 24, Issue 2, 752-763.
e_ISSN: 2598-8735
https://al-qodiri.unikhams.ac.id/index.php/alqodiri/index

Enhancing Financial Resilience through Green Innovation: The Mediating Effect of Operational Efficiency in Indonesian Energy Companies

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Article Info

Article history:

Received: April, 28, 2026
Revised: May, 29, 2026
Accepted: July, 01, 2026

Keywords:

Energy companies;
Financial resilience;
Green innovation;
Operational efficiency;
Resource-based view.

Abstract

Financial resilience has become increasingly important for energy companies facing economic uncertainty, transition risks, and growing sustainability pressures. Although green innovation is widely recognized as a strategic capability for improving environmental and business outcomes, its direct contribution to financial resilience remains unclear, particularly in emerging-market energy sectors. This study examines the effect of green innovation on financial resilience and investigates the mediating role of operational efficiency in energy companies listed on the Indonesia Stock Exchange during the 2021–2025 period. Using a quantitative explanatory design, this study analyzes balanced panel data from 20 energy companies, resulting in 100 firm-year observations. Financial resilience is proxied by cash holding, green innovation is measured using the Green Innovation Disclosure Index, and operational efficiency is proxied by asset turnover. Panel data regression is employed to test the direct effects, while the Sobel test is used to examine the mediation effect. The results show that green innovation does not directly affect financial resilience. However, green innovation has a positive and significant effect on operational efficiency, and operational efficiency positively affects financial resilience. The mediation test confirms that operational efficiency fully mediates the relationship between green innovation and financial resilience. These findings indicate that green innovation cannot be treated merely as environmental disclosure; it becomes financially meaningful only when transformed into an operational capability that improves asset utilization and efficiency. This study extends the Resource-Based View by showing that sustainability-oriented capabilities require an internal conversion mechanism before generating resilience outcomes. Practically, the findings suggest that energy companies should align green innovation initiatives with operational efficiency improvements to strengthen financial stability and long-term sustainability.

To cite this article: Saleh, R, A., Wahyuni, N, I., Arif, A. (2026). Enhancing Financial Resilience through Green Innovation: The Mediating Effect of Operational Efficiency in Indonesian Energy Companies. *Al Qodiri: Jurnal Pendidikan, Sosial dan Keagamaan, 24* (2), 752-763.

INTRODUCTION

The global energy sector is undergoing a major transformation as firms face increasing pressure from climate change, technological disruption, geopolitical uncertainty, and stricter sustainability expectations. In this changing environment, companies are required not only to maintain profitability but also to preserve financial stability when facing shocks and long-term transition risks. Financial resilience has therefore become a strategic capability because it reflects a firm's ability to maintain liquidity, absorb financial pressure, adapt to uncertainty, and sustain business continuity (Juan & Li, 2023; Zahedi et al., 2021). This issue is particularly important for

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energy companies because they operate in a sector characterized by high capital intensity, commodity price volatility, regulatory pressure, and exposure to environmental risks. Firms that lack financial resilience may struggle to finance transformation, maintain operations, and respond effectively to market and policy changes. Accordingly, examining the drivers of financial resilience is increasingly relevant in the fields of corporate finance, sustainability management, and energy transition studies.

The urgency of this issue is highly visible in Indonesia, where the energy sector remains central to national economic development while also being required to support the transition toward a low-carbon economy. Indonesia has committed to achieving net-zero emissions by 2060 or sooner, creating strong pressure for energy firms to adopt cleaner technologies, improve operational systems, and align their strategies with sustainability policies (Astuty et al., 2025; Nasir & Bengi, 2024). However, this transition is not financially neutral. Energy companies must deal with high investment needs, technological adaptation, asset restructuring, and uncertainty in future energy markets. These conditions create a dual challenge: firms must pursue sustainability-oriented transformation while maintaining liquidity and financial flexibility. Therefore, financial resilience becomes essential for Indonesian energy companies to survive transition pressures and remain competitive in the long term.

Green innovation is often considered a strategic response to environmental pressure because it enables firms to reduce resource consumption, minimize emissions, improve production processes, and develop more sustainable operational practices (Khanra et al., 2022; Le, 2022). From the Resource-Based View, green innovation can be understood as a strategic capability that may create competitive advantage when it is valuable, difficult to imitate, and effectively integrated into the firm's internal processes (Dang & Wang, 2022; Juo & Wang, 2022). Nevertheless, the financial benefits of green innovation are not always direct or immediate. Green innovation frequently requires substantial initial investment, managerial commitment, technological adjustment, and process redesign before it produces measurable economic value. In energy companies, this condition is even more complex because green innovation is closely related to capital-intensive assets and long-term transformation. Thus, green innovation should not be viewed merely as environmental disclosure, but as a strategic capability whose value depends on its ability to improve internal business operations.

Operational efficiency represents one of the most important mechanisms through which green innovation may be translated into financial resilience. Efficient firms are better able to optimize asset use, reduce waste, control operating costs, and generate more stable revenue from their existing resources (Hu et al., 2022; İncekara, 2022). In uncertain business conditions, these efficiency gains can strengthen liquidity, improve financial flexibility, and help firms absorb external shocks. For energy firms, operational efficiency is especially important because their business activities depend heavily on large assets, high operating costs, and exposure to changes in input prices and market demand. Green innovation may support efficiency through energy-saving technologies, cleaner production processes, waste reduction, and better environmental management systems. Therefore, the relationship between green innovation and financial resilience may not operate directly, but through the firm's ability to convert green initiatives into operational improvements.

Previous studies have widely examined the relationship between green innovation and corporate outcomes, but their dominant focus remains on financial performance, firm value, environmental performance, and competitive advantage. Xie et al., (2022) showed that green product and process innovation can improve corporate financial performance, while Hao et al., (2023) demonstrated that green innovation enhances economic performance through different improvement paths. Asni & Agustia, (2021) found that financial performance mediates the relationship between green innovation and firm value in ASEAN firms. Le et al., (2022) also emphasized the role of sustainability in linking green innovation to firm performance. More recent studies further indicate that green innovation is associated with ESG practices, environmental commitment, technological capability, operational outcomes, and financial performance (Khanchel et al., 2023; Long et al., 2023; Momin et al., 2026; Tripopsakul, 2025; Zhao et al., 2023; Zheng et al., 2022). However, these studies show that the effect of green innovation is not always direct, uniform, or immediate. Some findings suggest that green innovation improves firm outcomes, whereas others

indicate that its benefits depend on mediating mechanisms, internal capabilities, and contextual conditions.

Despite the growing body of literature, several important gaps remain unresolved. First, prior studies tend to treat green innovation as a direct driver of firm performance, while paying limited attention to how green innovation is transformed into financial resilience. Second, financial resilience has received less empirical attention than profitability, firm value, and environmental performance, even though resilience is crucial for firms operating under transition pressure and economic uncertainty. Third, studies on green innovation are still dominated by manufacturing firms, developed economies, or broad multi-sector samples, while evidence from emerging-market energy companies remains limited. Fourth, the role of operational efficiency as an internal capability that links green innovation with financial resilience has not been sufficiently examined. This creates a critical research gap: it remains unclear whether green innovation itself strengthens financial resilience or whether its effect only becomes meaningful when green innovation is converted into operational efficiency.

Based on this gap, this study aims to examine the effect of green innovation on financial resilience and to investigate the mediating role of operational efficiency in energy companies listed on the Indonesia Stock Exchange during the 2021–2025 period. Unlike previous studies that mainly position green innovation as a direct determinant of financial performance or firm value, this study argues that green innovation strengthens financial resilience only when it is translated into operational efficiency. This study contributes theoretically by extending the Resource-Based View, showing that sustainability-oriented capabilities do not automatically generate resilience unless they are supported by complementary operational capabilities. It also contributes empirically by providing evidence from Indonesia's energy sector, an emerging-market context facing simultaneous pressures from energy transition, commodity volatility, regulatory change, and capital-intensive transformation. Practically, the findings are expected to help managers, investors, and policymakers understand that green innovation should be directed not only toward environmental legitimacy, but also toward efficiency improvement that strengthens long-term financial resilience.

METHOD

Research Design

This study employed a quantitative explanatory research design to examine the relationship between green innovation, operational efficiency, and financial resilience. This design was considered appropriate because the study aimed to test causal relationships among measurable firm-level variables using statistical analysis. The research used panel data regression because the data combined cross-sectional information from several companies and time-series information across a five-year observation period. This approach allowed the study to capture differences among firms and changes in firm conditions over time. The use of panel data also provided more efficient estimates than a purely cross-sectional or time-series design.

Research Context and Period

The study was conducted in the context of energy sector companies listed on the Indonesia Stock Exchange. The energy sector was selected because it is highly relevant to the issue of sustainability transformation, energy transition, and financial resilience. Energy companies operate in a capital-intensive industry and are exposed to commodity price volatility, regulatory pressure, and environmental demands. The observation period covered 2021–2025. This period was chosen because it reflects the post-pandemic recovery phase and the increasing pressure on Indonesian energy companies to align their business strategies with sustainability and net-zero emission agendas.

Population and Sample

The population of this study consisted of all energy sector companies listed on the Indonesia Stock Exchange during the 2021–2025 period. The sample was selected using purposive sampling. The inclusion criteria were: companies consistently listed in the energy sector during the observation period, companies that published annual reports and/or sustainability reports, and companies with complete data for all research variables. Companies that did not provide complete financial or sustainability disclosure data were excluded. Based on these criteria, 20 companies were selected,

resulting in 100 firm-year observations. This sampling technique was used because the study required complete and comparable financial and non-financial data across the observation period.

Data Sources and Research Instruments

This study used secondary data obtained from annual reports, sustainability reports, audited financial statements, company websites, and official publications of the Indonesia Stock Exchange. The main research instrument was a documentation checklist used to collect financial data and code green innovation disclosure. Financial resilience, operational efficiency, leverage, and liquidity were measured using financial ratios derived from audited financial statements. Green innovation was measured through content analysis of annual and sustainability reports using the Green Innovation Disclosure Index. The index covered disclosure related to energy efficiency, resource conservation, waste and emission management, environmentally friendly technology, and environmental management practices. This measurement approach was adapted from previous studies on green innovation and disclosure-based assessment (Li et al., 2023; Skinner & Valentine, 2026).

Variable Measurement

Table 1 presents the operational definition of each variable used in this study.

Table 1. Operational Definition of Variables

Variable	Proxy	Formula	Operational Definition	Updated Reference
Financial resilience	Cash holding	Cash and cash equivalents / Total assets	Measures the firm's liquidity buffer and ability to withstand financial pressure.	Danarsari, (2022); Homayoun et al., (2024)
Green innovation	Green Innovation Disclosure Index	Total disclosed green innovation items / Total GIDI items	Measures the extent of firm disclosure related to energy efficiency, resource conservation, waste reduction, emission management, and green technology.	Asni & Agustia, (2021); Cheng et al., (2025)
Operational efficiency	Asset turnover	Sales / Total assets	Measures the firm's ability to use its assets efficiently to generate revenue.	Lou et al., (2025); Cheng et al., (2025); Sriani et al. (2024)
Leverage	Debt-to-equity ratio	Total debt / Total equity	Controls for the firm's capital structure and financing risk.	Andini et al. (2026)
Liquidity	Current ratio	Current assets / Current liabilities	Controls for the firm's short-term liquidity capacity.	Sriani et al. (2024); Andini et al. (2026)

Financial resilience was proxied by cash holding because cash and cash equivalents represent the most liquid resources available to firms in responding to financial pressure. Green innovation was measured using a disclosure index because green innovation activities are commonly reported through annual and sustainability reports. Operational efficiency was proxied by asset turnover because it reflects how effectively a firm uses its total assets to generate sales. Debt-to-equity ratio and current ratio were included as control variables to account for differences in capital structure and liquidity conditions among firms.

Validity and Reliability of Measurement

The validity of the measurement was ensured through theoretical validity and content validity. The indicators of green innovation were adapted from established prior studies and adjusted to the context of energy sector companies. To reduce subjectivity in content analysis, the coding process followed a structured checklist with predetermined disclosure categories. Each item was scored 1 if disclosed and 0 if not disclosed. The final Green Innovation Disclosure Index score was calculated by dividing the total disclosed items by the total number of items in the index. Because this study used secondary data and financial ratios rather than survey-based instruments, reliability testing such as Cronbach's alpha was not required. Reliability was strengthened through repeated

checking, consistent coding rules, and cross-verification between annual reports, sustainability reports, and financial statements.

Data Collection Procedure

The data collection process was carried out in several stages. First, energy sector companies listed on the Indonesia Stock Exchange during 2021–2025 were identified. Second, companies were screened based on the inclusion and exclusion criteria. Third, annual reports, sustainability reports, and financial statements were collected from the IDX website and company websites. Fourth, financial data were extracted and used to calculate cash holding, asset turnover, debt-to-equity ratio, and current ratio. Fifth, green innovation disclosure was coded using the Green Innovation Disclosure Index checklist. Finally, all data were arranged into a balanced panel dataset consisting of 20 companies observed over five years.

Data Analysis Technique

The data were analyzed using EViews software. The analysis began with descriptive statistics to describe the distribution, mean, maximum, minimum, and standard deviation of each variable. Panel data model selection was then conducted using the Chow test, Hausman test, and Lagrange Multiplier test to determine the most appropriate estimation model among the Common Effect Model, Fixed Effect Model, and Random Effect Model. Classical assumption tests were conducted to examine multicollinearity, heteroscedasticity, and autocorrelation. The hypotheses were tested using panel data regression at a 5% significance level.

The empirical models used in this study are presented as follows:

$$FR_{it} = \alpha + \beta_1 GI_{it} + \beta_2 OE_{it} + \beta_3 DER_{it} + \beta_4 CR_{it} + \varepsilon_{it}$$

$$OE_{it} = \alpha + \beta_1 GI_{it} + \beta_2 DER_{it} + \beta_3 CR_{it} + \varepsilon_{it}$$

Where:

FR_{it} = Financial resilience of firm i in year t.
GI_{it} = Green innovation of firm i in year t, measured using the Green Innovation Disclosure Index (GIDI).
OE_{it} = Operational efficiency of firm i in year t, proxied by Asset Turnover (ATO).
DER_{it} = Debt-to-Equity Ratio of firm i in year t.
CR_{it} = Current Ratio of firm i in year t.
α = Constant (intercept).
β_1–β_4 = Estimated regression coefficients.
ε_{it} = Random error term.
i = Individual firm.
t = Observation year (2021–2025).

The first equation estimates the direct effects of green innovation, operational efficiency, leverage, and liquidity on financial resilience. The second equation estimates the effect of green innovation on operational efficiency, which serves as the mediator in the proposed research model. The indirect effect of green innovation on financial resilience through operational efficiency was subsequently examined using the Sobel test (Sobel, 1982).

Research Ethics

This study used publicly available secondary data and did not involve human participants, interviews, surveys, or experiments. Therefore, informed consent, respondent anonymity, and personal data protection were not applicable in the same way as primary data research. Nevertheless, the study followed academic ethical principles by using official data sources, maintaining data accuracy, avoiding data manipulation, and reporting the research procedures transparently. All sources used in the study were properly acknowledged. The data were analyzed only at the firm level and used solely for academic purposes.

RESULTS AND DISCUSSION

Results

This section presents the empirical findings obtained from the analysis of 100 firm-year observations from 20 energy companies listed on the Indonesia Stock Exchange during the 2021–2025 period. The results are organized into five parts: descriptive statistics, panel data model selection, classical assumption tests, panel regression results, and mediation effect testing. The presentation is designed to show the distribution of the variables, the adequacy of the estimation model, and the statistical evidence for each proposed hypothesis.

Descriptive Statistics

Descriptive statistics were used to examine the distribution, central tendency, and variability of the main research variables. The results are presented in Table 1.

Table 2. Descriptive Statistics

Statistic	Financial Resilience	Green Innovation	Operational Efficiency
Mean	0.193463	0.913750	0.823604
Median	0.136188	1.000000	0.785923
Maximum	0.862311	1.000000	2.092031
Minimum	0.001097	0.375000	0.010271
Std. Dev.	0.179494	0.127741	0.435549
Observations	100	100	100

Source: Authors' calculations (2026).

Table 2 shows that Financial Resilience has a mean value of 0.193463, indicating that cash and cash equivalents account for approximately 19.35% of total assets on average. The median value of 0.136188 is lower than the mean, suggesting that more than half of the observations have cash holdings below the average level. The minimum value of 0.001097 and maximum value of 0.862311 indicate substantial differences in liquidity buffer capacity among the sample firms. This variation suggests that Indonesian energy companies differ considerably in their ability to maintain cash reserves and absorb financial pressure.

Green Innovation has a mean value of 0.913750 and a median value of 1.000000. These values indicate that most sample firms disclose green innovation practices at a relatively high level. The maximum value of 1.000000 shows that several firms disclosed all items in the Green Innovation Disclosure Index, while the minimum value of 0.375000 indicates that some firms still had limited disclosure. The standard deviation of 0.127741 suggests that green innovation disclosure is relatively homogeneous across the sample.

Operational Efficiency has a mean value of 0.823604 and a median value of 0.785923. The variable ranges from 0.010271 to 2.092031, indicating wide differences in firms' ability to utilize assets to generate revenue. The standard deviation of 0.435549 is higher than that of Green Innovation, showing that operational efficiency varies more strongly across companies. Overall, the descriptive results indicate that although green innovation disclosure is relatively high, firms differ substantially in operational efficiency and financial resilience.

Panel Data Model Selection

Panel data model selection was conducted to identify the most appropriate estimation model for each empirical equation. The Chow test was used to compare the Common Effect Model and Fixed Effect Model. The Hausman test was used to compare the Fixed Effect Model and Random Effect Model, while the Lagrange Multiplier test was used to compare the Common Effect Model and Random Effect Model. The results are presented in Table 2.

Table 3. Panel Data Model Selection Results

Equation	Chow Test	Hausman Test	LM Test	Selected Model
Equation 1	0.0000	0.0481	0.0000	Fixed Effect Model
Equation 2	0.0000	0.3594	0.0000	Random Effect Model

Source: Authors' calculations (2026).

Table 3 indicates that Equation 1 is most appropriately estimated using the Fixed Effect Model. This is shown by the Chow test probability of 0.0000 and the Hausman test probability of 0.0481,

which indicate that firm-specific effects need to be considered when estimating the determinants of Financial Resilience. For Equation 2, the Chow test and LM test indicate the presence of panel effects, while the Hausman test probability of 0.3594 supports the use of the Random Effect Model. Therefore, the subsequent regression analysis used the Fixed Effect Model for Equation 1 and the Random Effect Model for Equation 2.

Classical Assumption Tests

Classical assumption tests were conducted before hypothesis testing to ensure that the regression models were statistically adequate. The multicollinearity test showed that all correlation coefficients among the independent variables were below 0.80, indicating that the model did not suffer from serious multicollinearity. The heteroscedasticity test using the Glejser approach showed probability values above 0.05 for all variables, indicating that heteroscedasticity was not detected. The Durbin–Watson statistics were 1.996 for Equation 1 and 1.469 for Equation 2, suggesting that the models did not show serious autocorrelation problems. Based on these results, the regression models were considered appropriate for hypothesis testing.

Panel Regression Results

The hypotheses were tested using panel data regression based on the selected estimation model for each equation. Equation 1 examined the effects of Green Innovation and Operational Efficiency on Financial Resilience, with Debt-to-Equity Ratio and Liquidity as control variables. Equation 2 examined the effect of Green Innovation on Operational Efficiency, also controlling for Debt-to-Equity Ratio and Liquidity. The results are presented in Table 3.

Table 4. Panel Regression Results

Dependent Variable	Independent Variable	Coefficient	Std. Error	t-statistic	P-value
Financial Resilience	C	0.004335	0.100548	0.043110	0.9657
Financial Resilience	Green Innovation	-0.051161	0.120676	-0.423956	0.6728
Financial Resilience	Operational Efficiency	0.203241	0.060285	3.371343	0.0012
Financial Resilience	DER	0.011195	0.013451	0.832258	0.4079
Financial Resilience	Liquidity	0.031242	0.014213	2.198153	0.0310
Financial Resilience	R-squared	0.776231			
Financial Resilience	Prob. F-statistic	0.000000			
Operational Efficiency	C	0.112179	0.202852	0.553009	0.5815
Operational Efficiency	Green Innovation	0.886532	0.199911	4.434636	0.0000
Operational Efficiency	DER	-0.004025	0.023198	-0.173520	0.8626
Operational Efficiency	Liquidity	-0.052708	0.025592	-2.059536	0.0421
Operational Efficiency	R-squared	0.181885			
Operational Efficiency	Prob. F-statistic	0.000229			

Source: Authors' calculations (2026).

Table 4 shows that Green Innovation has no significant direct effect on Financial Resilience, as indicated by a coefficient of -0.051161 and a p-value of 0.6728. This result means that H1 is not supported. In contrast, Operational Efficiency has a positive and significant effect on Financial Resilience, with a coefficient of 0.203241 and a p-value of 0.0012. This result supports H2 and indicates that firms with higher operational efficiency tend to have stronger financial resilience.

Among the control variables in Equation 1, Liquidity has a positive and significant effect on Financial Resilience, with a coefficient of 0.031242 and a p-value of 0.0310. This indicates that firms with stronger short-term liquidity positions tend to maintain higher financial resilience. DER has a positive but insignificant effect, suggesting that leverage does not significantly explain variation in Financial Resilience in this model. The R-squared value of 0.776231 indicates that Equation 1 explains 77.62% of the variation in Financial Resilience, while the probability value of the F-statistic confirms that the model is statistically significant.

The results of Equation 2 show that Green Innovation has a positive and significant effect on Operational Efficiency, with a coefficient of 0.886532 and a p-value of 0.0000. This finding indicates that firms with higher green innovation disclosure tend to demonstrate higher operational efficiency. DER does not significantly affect Operational Efficiency, as shown by a p-value of 0.8626. Liquidity has a negative and significant effect on Operational Efficiency, with a coefficient of -0.052708 and a

p-value of 0.0421. The R-squared value of 0.181885 indicates that Equation 2 explains 18.19% of the variation in Operational Efficiency. Although the explanatory power is lower than Equation 1, the probability value of the F-statistic confirms that the model is statistically significant.

Mediation Effect Test

The mediating effect of Operational Efficiency in the relationship between Green Innovation and Financial Resilience was examined using the Sobel test. This test was conducted to determine whether the indirect effect of Green Innovation on Financial Resilience through Operational Efficiency was statistically significant. The results are presented in Table 4.

Table 5. Mediation Effect Test Results

Hypothesis	Path Tested	Z-score	P-value	Decision
H3	Green Innovation → Operational Efficiency → Financial Resilience	2.684	0.0073	Supported

Source: Authors' calculations (2026).

Table 5 shows that the Sobel test produced a Z-score of 2.684 and a p-value of 0.0073. Since the p-value is below 0.05, the indirect effect of Green Innovation on Financial Resilience through Operational Efficiency is statistically significant. The indirect effect was calculated by multiplying the coefficient of Green Innovation on Operational Efficiency by the coefficient of Operational Efficiency on Financial Resilience, resulting in an indirect effect of 0.1802. This result indicates that Operational Efficiency significantly mediates the relationship between Green Innovation and Financial Resilience.

The mediation result also shows that the direct effect of Green Innovation on Financial Resilience is not significant, whereas the indirect effect through Operational Efficiency is significant. This pattern indicates full mediation. In other words, Green Innovation does not directly strengthen Financial Resilience, but contributes to Financial Resilience when it is translated into improvements in Operational Efficiency. Therefore, H3 is supported.

Summary of Hypothesis Testing

Overall, the empirical findings show that H1 is not supported, while H2 and H3 are supported. Green Innovation does not have a significant direct effect on Financial Resilience. However, Green Innovation significantly improves Operational Efficiency, and Operational Efficiency significantly enhances Financial Resilience. These results indicate that Operational Efficiency plays a central role in converting Green Innovation into Financial Resilience among Indonesian energy companies.

Discusion

The finding that Green Innovation does not directly affect Financial Resilience provides an important insight into the complex relationship between sustainability-oriented innovation and financial stability. Although green innovation is theoretically expected to strengthen firm capability, the result suggests that its financial benefit is not automatically reflected in cash-based resilience. From the Resource-Based View, a strategic capability can create value only when it is effectively deployed, integrated, and transformed into operational or financial advantage. In the context of Indonesian energy companies, green innovation may still function more as a compliance-oriented or legitimacy-driven practice than as a fully integrated financial capability. This finding is consistent with studies showing that the effects of green innovation on firm outcomes are often indirect, delayed, or dependent on internal organizational conditions (Asni & Agustia, 2021; Cheng et al., 2025; Khanchel et al., 2023; Tripopsakul, 2025). It also differs from studies that report a direct positive effect of green innovation on firm performance, which may be explained by differences in sectoral characteristics, regulatory maturity, and the intensity of green technology adoption. Therefore, this study indicates that green innovation alone is not sufficient to strengthen financial resilience unless it is translated into measurable operational improvements.

The positive effect of Operational Efficiency on Financial Resilience confirms that efficient resource utilization plays a central role in strengthening a firm's capacity to withstand financial pressure. This result shows that firms with better asset utilization are more capable of maintaining liquidity, controlling costs, and generating stable revenue from their existing resources. Conceptually, this finding supports the Resource-Based View because operational efficiency represents an internal capability that enables firms to convert resources into stronger organizational outcomes. In capital-intensive sectors such as energy, efficiency is particularly important because

firms face high fixed costs, large asset bases, and exposure to market volatility. This result is in line with prior studies emphasizing that operational efficiency, cost control, and resource optimization contribute to stronger financial and organizational resilience (Homayoun et al., 2024; Hu et al., 2022; İncekara, 2022; Lou et al., 2025). The finding also strengthens the argument that financial resilience should not be understood only as a liquidity condition, but also as the outcome of effective operational capability. Thus, operational efficiency becomes a practical pathway through which energy companies can improve their financial buffer and maintain stability under transition pressures.

The significant positive effect of Green Innovation on Operational Efficiency indicates that sustainability-oriented innovation can improve how firms utilize resources and manage operational processes. This finding suggests that green innovation is valuable not merely because it signals environmental responsibility, but because it can support energy savings, waste reduction, process improvement, and more efficient asset use. From a Resource-Based View perspective, green innovation becomes meaningful when it enhances internal capabilities that directly influence firm operations. This result is consistent with previous studies showing that green process innovation, green technology adoption, and environmental management practices can improve efficiency and operational outcomes (Khanra et al., 2022; Le, 2022; Long et al., 2023; Momin et al., 2026; Zheng et al., 2022). However, the relatively lower explanatory power of the operational efficiency model also implies that green innovation is not the only factor shaping efficiency. Other elements such as technology readiness, managerial capability, production scale, asset structure, and market conditions may also determine how effectively green practices improve operations. This finding therefore positions green innovation as an important but not standalone driver of efficiency in Indonesian energy firms.

The mediation result provides the strongest theoretical contribution of this study by showing that Operational Efficiency fully mediates the relationship between Green Innovation and Financial Resilience. This means that green innovation does not directly strengthen financial resilience, but becomes financially meaningful when it is converted into higher operational efficiency. The finding extends the Resource-Based View by demonstrating that sustainability-oriented resources and capabilities require an internal conversion mechanism before producing resilience outcomes. This result also clarifies why previous studies have reported mixed findings on the financial effects of green innovation. Studies that find a direct positive effect may capture contexts where green innovation is already embedded in operational systems, while studies that find weak or insignificant effects may reflect conditions where green initiatives remain symbolic, fragmented, or not yet operationally effective (Asni & Agustia, 2021; Hao et al., 2023; Le et al., 2022; Tripopsakul, 2025; Zhao et al., 2023). In the Indonesian energy sector, where firms are simultaneously exposed to energy transition pressure, commodity volatility, and capital-intensive transformation, operational efficiency becomes the missing link that determines whether green innovation can support financial resilience. Therefore, this study contributes a more nuanced explanation: green innovation strengthens resilience not by its existence, but by its operational consequences.

Overall, the findings place this study within the global literature on green innovation, firm resilience, and sustainable finance by offering evidence from an emerging-market energy sector. The results challenge the assumption that green innovation automatically produces financial benefits and instead show that resilience depends on the firm's ability to internalize green innovation into efficient operations. This perspective is important because many energy firms may disclose green innovation activities, but disclosure alone does not guarantee stronger financial capacity. For managers, the findings imply that green innovation strategies should be evaluated not only through environmental indicators, but also through their contribution to asset productivity, cost reduction, and liquidity strength. For investors and policymakers, the study suggests that green transition policies should encourage firms to connect sustainability initiatives with operational transformation rather than treating green disclosure as an isolated objective. Compared with previous studies that mainly focus on profitability, firm value, or environmental performance, this study advances the literature by positioning financial resilience as a strategic outcome of green innovation through operational efficiency. In this sense, the novelty of the study lies in explaining the mechanism through which green innovation becomes financially relevant in the context of Indonesian energy companies.

CONCLUSION

This study examined the effect of Green Innovation on Financial Resilience and the mediating role of Operational Efficiency in energy companies listed on the Indonesia Stock Exchange during the 2021–2025 period. The findings show that Green Innovation does not directly improve Financial Resilience, indicating that sustainability-oriented innovation is not automatically converted into stronger financial capacity. However, Green Innovation has a positive effect on Operational Efficiency, and Operational Efficiency significantly enhances Financial Resilience. The mediation test further confirms that Operational Efficiency fully mediates the relationship between Green Innovation and Financial Resilience. These results indicate that green innovation becomes financially meaningful only when it is translated into more efficient operational processes.

Theoretically, this study extends the Resource-Based View by demonstrating that strategic sustainability capabilities require an internal conversion mechanism before generating resilience-related outcomes. Green Innovation should therefore be understood not merely as an environmental commitment or disclosure practice, but as a capability that must improve asset utilization, cost efficiency, and operational productivity to strengthen financial resilience. Practically, the findings suggest that Indonesian energy companies need to align green innovation initiatives with operational transformation. Managers should ensure that investments in green technology, energy efficiency, waste reduction, and environmental management produce measurable improvements in operational efficiency. For policymakers and investors, the findings highlight the importance of evaluating green innovation not only from an environmental perspective, but also from its ability to support financial stability and long-term resilience.

This study has several limitations that may guide future research. First, financial resilience was measured using cash holding, while future studies may use broader resilience indicators such as financial flexibility, cash flow stability, debt maturity structure, or composite resilience indices. Second, Green Innovation was measured through disclosure-based indicators, which may not fully capture the actual quality or intensity of innovation implementation. Future research may consider using patent data, green investment intensity, carbon reduction performance, or ESG-based innovation measures. Third, this study focused only on Indonesian energy companies during the 2021–2025 period, so future studies may expand the analysis to other sectors, longer observation periods, or cross-country comparisons. Further studies may also apply alternative mediation techniques, such as bootstrapping or dynamic panel models, to provide stronger evidence on the causal mechanism linking green innovation, operational efficiency, and financial resilience.

AUTHOR CONTRIBUTIONS STATEMENT

Rival Adha Saleh conceived the research idea, developed the study design, collected and organized the data, conducted the formal data analysis, interpreted the findings, and prepared the original manuscript draft. Nining Ika Wahyuni contributed to the research methodology, supervised the overall research process, critically reviewed the theoretical framework and data interpretation, and substantially revised the manuscript to improve its academic quality and intellectual content. Alfi Arif contributed to data validation, assisted in the interpretation of the empirical findings, reviewed the statistical analysis and presentation of results, and participated in manuscript editing and final refinement.

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