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Do Environmental Strategy Policies Improve Financial Performance? the Moderating Role of Board Gender Diversity

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Abstract

Environmental strategies are important in modern business, but evidence of their benefits is mixed. The board of directors plays a key role in shaping these strategies, and a diverse board can influence decision-making on environmental strategies. However, the influence of board diversity is still unclear, especially in Indonesia. This research investigates how environmental strategies relate to financial performance and explores the moderating effect of women on the board. Environmental strategies are measured through energy efficiency policy, emission reduction policy, and environmental supply chain management, while financial performance is measured by Return on Assets (ROA). Quantitative panel data regression is used to obtain the results. The study employs purposive sampling to select the sample, resulting in 1,205 unbalanced firm-year observations from 200 firms. This study uses random-effects panel regression with firm-clustered standard errors and robustness tests. Results show energy efficiency policy is positively associated with ROA; emission reduction is negatively associated with ROA, and environmental supply chain management is marginally and negatively associated with ROA. Women on the board significantly moderate the relationships between energy efficiency, environmental supply chain management, and ROA, but not emission reduction. These findings hold after adding year and industry fixed effects. However, the results do not hold with a one-year lag, which means that the association is immediate rather than delayed. This challenges the assumption that environmental strategies consistently benefit or influence financial performance. The study also offers practical and theoretical implications.

KEYWORDS

board gender diversity; environmental strategies; emission reduction policy; energy efficiency policy; financial performance; supply chain management.

Introduction

Environmental strategies have become a pivotal part of a firm's strategy (Hristov et al., 2022; Nguyen & Kanbach, 2024). Firms are pursuing more sustainable practices through environmental strategies, such as energy efficiency, emissions reductions, and sustainable supply chains (Micheli et al., 2020; Onukwulu et al., 2025). On the other hand, stakeholders such as regulators and creditors expect firms to embed environmentally friendly practices in their operations, rather than merely comply (Do & Nguyen, 2020). Moreover, investors perceive firms that apply sustainable environmental practices as a risk-reduction strategy that can reduce information asymmetry when they disclose their environmental practices (Landi et al., 2022; Yu et al., 2021). Therefore, environmental strategies play an important role in today's business practices.

Firms that develop environmentally friendly practices expect to reap the benefits in the form of increased performance. Do & Nguyen (2020) explain that improvements in short- and long-term performance are associated with proactive environmental activities. Moreover, Cho (2022), Tan et al. (2022), and Annesi et al. (2025) found that firms engaging in environmentally friendly activities tend to be more competitive and, consequently, to boost performance. Farag (2025) elaborates that environmental

practices help firms strengthen their relationships with related stakeholders by increasing trust. However, the positive impacts of environmental practices are not always the case. Zhang & Ma (2021) highlight the problem. They note that environmental strategies have an inconsistent impact on the firm's performance. Arbelo-Pérez et al. (2022) also suggest a similar phenomenon in which a firm's environmental strategies yield mixed results, with the strategy sometimes improving performance and at other times deterring it. Hasu et al. (2025) found that firms engaging with environmental strategy shows negative relationship with financial performance. Gutiérrez-Ponce & Wibowo (2023) confirm that environmental activities reduce the firm's financial performance. Therefore, despite the benefits of environmental strategies, empirical evidence remains mixed.

The aggregation of environmental scores may simplify many complex policies within the framework into a single number. This approach may cause important details that contribute to the environmental scores to be overlooked. When environmental scores are broken down into individual items such as energy efficiency, emissions reduction, and environmental supply chain management, the impact of each item on financial performance can be examined (Arvidsson & Dumay, 2022; Menicucci & Paolucci, 2023; Treepongkaruna et al., 2024). Energy efficiency refers to optimizing energy consumption across the business's operations (Vandana et al., 2021). Emission reduction is the process of lowering greenhouse gases through various environmentally friendly policies (Abbasi & Erdebili, 2023). Environmental supply chain management integrates environmental activities across all stages of the supply chain (Xu et al., 2023).

Environmental strategic actions are heavily dependent on the firm's governance. The firm's board is responsible for strategic resource allocation and will determine whether the firm will pursue active environmental practices or not (Zhu et al., 2024). For instance, a board with a long-term vision-oriented will more likely invest in more sustainable practices such as environmental strategies (Sul et al., 2025). A board with more experienced members tends to formulate green innovation and environmental strategies to improve the strategic decision-making (Karasamani et al., 2026). Moreover, a board composed of environmental experts will often draw the firm's attention to environmental practices, helping shape it to a higher level (Asad et al., 2025). Furthermore, a diverse board is an important characteristic that can help the firm shape its environmental strategies (Hu & Yang, 2021).

A diverse board can powerfully influence environmental strategic decision-making. A board that is diverse in gender, education, and experience can enhance decision-making by providing a broad perspective when discussing strategic ideas (Dwekat et al., 2025; Jeyhunov et al., 2025). In fact, a more gender-diverse firm can make better strategic decisions, especially in environmental practices (Issa, 2023; Lin et al., 2022). Moreover, a gender-diverse board can influence environmental strategic decision-making through more robust environmental risk management and practices (Al-Najjar & Salama, 2022; Oyewo, 2023).

Previous studies have documented how a gender-diverse board influences environmental decision-making in Indonesia. Aulia & Qurrota A'yun (2025) found that firms with female board members file fewer environmental lawsuits, spend more on environmental compliance, and tend to adopt more proactive sustainability measures. Moreover, Tjahjadi et al. (2024) prove that in manufacturing firms, a gender-diverse board increases its environmental responsibility engagement. This shows that environmental practices are not mere compliance but part of the firm's strategy. Perdana et al. (2024) report that a diverse board is associated with more transparent environmental strategies, as reflected in the

disclosures they provide. Nursulistyo and Putri (2025) note that boards with more women tend to pay more attention to environmental activities, as evidenced by greater environmental disclosure.

While a gender-diverse board can be seen as a key strategy to enhance environmental practices, its role in elevating environmental practices to improve financial performance remains inconclusive. For instance, Julianto et al. (2025) found that environmental practices create a positive link to firm value, which is weakened by the effect of a gender-diverse board. Yuniarti et al. (2025) found the positive moderation effect of gender diversity on the relationship between environmental disclosure and firm performance. Both of these studies examine the moderation role of board gender diversity by using only a single aggregate disclosure measure. This study fills the gap by examining separate environmental policies rather than a single constructed environmental score. This study also explores environmental strategies in the context of Indonesia's emerging market, as prior literature provides limited evidence on disaggregating environmental policies into distinct categories. Theoretically, agency theory views environmental policies as a tool to improve monitoring practices, but it can also increase the probability of overinvestment, creating theoretical ambiguity regarding environmental practices.

Agency theory explains that the environmental strategies can produce diverse results on financial performance. Environmental strategies, along with strong governance practices such as a diverse board, can improve the monitoring function and thus lead to positive financial performance (Angsoyiri et al., 2025). In fact, environmental strategies may reduce information asymmetry, thereby improving financial outcomes (Wu & Xu, 2024). On the other hand, environmental policies are tools managers can use to pursue personal interests, such as reputation, which can lead to lower financial performance. Thus, an overinvestment in reputation may harm financial performance (Singh et al., 2025). Moreover, higher corporate governance quality, such as a diverse board, does not automatically translate sustainable decision-making into a profitable outcome; it may actually hinder it (Båtae et al., 2021).

Environmental strategies are key to sustaining competitive advantage in today's business environment. Studies have proven that better management of environmental performance is associated with profit growth. This is due to the efficiency it produces, which generates cost leadership and eventually increases the profit margin. Moreover, environmental practices positively impact overall market and operational performance (Do & Nguyen, 2020; Nogueira et al., 2023; Yadav et al., 2017). Furthermore, environmental sustainability not only improves financial outcomes but also improves other key factors in the firm. For instance, environmental strategies may balance non-financial measures with financial measures by improving customer, internal process, and learning & growth performance (Gupta & Gupta, 2020).

Firms investing in energy-efficiency policies may improve or worsen financial outcomes. Energy efficiency is a problem of unmonitored managerial discretion since the decision maker often do not bear the energy costs from their decision. A formal energy efficiency policy is then used as an effective strategy to reduce the agency problem (Longarela-Ares et al., 2020). Moreover, when firms increase their energy efficiency, they experience lower energy bills and improved operational efficiency, leading to higher financial performance. Moreover, a policy focused on the long term, such as energy efficiency, can increase innovation and lead to positive financial outcomes. Thus, a well-designed energy-efficiency policy may increase financial outcomes through the operational efficiency and innovation it produces (Daud et al., 2023; L. W. Fan et al., 2017; Lui et al., 2021; Salehi et al., 2025). On the other hand, energy efficiency policy may entail high costs due to the capital

expenditure and ongoing maintenance required. Energy efficiency policies that produce energy-efficient products are typically more expensive than conventional products. This causes an increase in operating costs, which will depress the financial outcome. Energy efficiency policy can also be applied because of regulatory pressures. The pressure pushes the firm to comply with regulations and create compliance costs, which will erode the financial outcome (Lui et al., 2021; Sharma et al., 2023). Thus, it can be hypothesized:

H1: Energy efficiency policy affects the firm's financial performance

Emission reductions implemented by firms can affect financial performance. According to agency theory, emission reduction is not only a mere efficiency improvement, but also involves the reshaping of investment plans and addressing agency problems. Emission reduction can be associated with overinvestment (Jebri et al., 2024). Its purpose is to reduce the emissions induced by the operation, transforming it into an efficient energy operation that reduces pollution-related costs, environmental liabilities, and provides an improvement in profitability. It also reduces environmental risks and production costs, thereby improving environmental performance and potentially increasing financial performance (Ighrarah & Khalifa, 2025; Secinaro et al., 2020). Emission reduction can also lower the firm's cost of capital and support profitability (Emous et al., 2021). While emission reductions can increase financial performance, several studies find the opposite. T. Lu et al. (2025) argue that emission reductions will lead to capital-intensive investment in new equipment or renewable energy, which will reduce commitment to productive investment that increases earnings, eventually causing a decrease in financial performance. Z. Huang et al. (2025) argue that emission reduction can increase capital expenditure and erode efficiency in the short term, which causes a decrease in financial outcome. Yang & Xu (2024) confirm that emission reductions may increase production costs through the use of low-carbon inputs, thereby increasing product costs and decreasing financial performance. It can be hypothesized:

H2: Emission reduction affects the firm's financial performance

Environmental supply chain management can also affect financial outcomes. Moreover, firms that embed environmentally friendly supply chain management practices experience improved environmental performance, which eventually leads to improved financial performance (Kalyar et al., 2019). It can also support the firm strategically. Environmental supply chain management creates a strong link between the information sharing, logistic networking, and transportation practices that sustain the business and boost the financial performance (Trivellas et al., 2020). On the other hand, green supply chain management creates a higher operating and compliance cost. It increases cost by the new processes, which include cleaner production, waste segregation, and green purchasing. It may increase the environmental performance, but it can cause a decrease in profitability in the short term (Esfahbodi et al., 2016; Rupa & Saif, 2022; Zeng et al., 2022). It can be hypothesized:

H3: Environmental supply chain management affects the firm's financial performance

A gender-diverse board can impact the relationship between environmental strategies and financial performance. Agency theory treats board gender diversity as a monitoring mechanism that can benefit the firm by mitigating agency problems, but it can also incur additional costs through increased monitoring. Female members on the board are, on average, more focused on ethical issues and stakeholders, and may monitor management more intensively. It creates a more holistic approach in developing environmental strategies (Almaqtari et al., 2024; Xie et al., 2020). Alodat &

Hao (2025) explain that when more women are on the board, it can affect the environmental impact on the financial performance. Orazalin & Baydauletov (2020) also added that more diverse the board, the higher the monitoring, which will eventually influence the environmental strategies impact on financial outcome. Therefore, it can be hypothesized:

H4: The proportion of women on the board moderates the relationship between energy efficiency policy and the firm's financial performance

H5: The proportion of women on the board moderates the relationship between emission reduction and the firm's financial performance

H6: The proportion of women on the board moderates the relationship between environmental supply chain management and the firm's financial performance

Methods

This study employs a quantitative panel data regression approach to examine the impact of environmental strategies on financial performance and the moderating effect of board gender diversity. A purposive sampling method is employed. The sample consists of Indonesian companies that have fulfilled the sampling requirements as follows: 1. Data on energy efficiency policy, emission reduction, and environmental supply chain management policy are available on Bloomberg Terminal; 2. Data on return on assets are available on the Bloomberg Terminal; 3. Data on the percentage of women on boards are available on the Bloomberg Terminal. Applying these criteria to the initial population leaves 200 firms with complete data on all required fields, or 19.8% of the population. Firms are excluded solely on data availability. No exclusion is made on the basis of sector, size, or listing status. Regarding the firm's industry, no sector was excluded. All sectors listed on the Indonesia Stock Exchange are eligible for inclusion, and financial sector firms are retained wherever the required Bloomberg fields are available. The final sample consists of 11 Global Industry Classification Standard (GICS) sectors. The financial sector is the largest group with 42 firms and 238 firm-year observations, followed by Materials (33 firms, 199 firm-year observations), and consumer staples (32 firms, 197 firm-year observations). Finally, after considering the sample requirement, a total of 1,205 firm-year observations are used in this research. Table 1, panel A, presents the distribution of the initial population and the final sample by year, while panel B lists the sectoral distribution of the observations. The panel is unbalanced because Bloomberg's environmental data coverage of Indonesian issuers expanded over the observation period rather than because firms exited the sample (Table 2). The number of firms covered rises from 67 in 2015 to 192 in 2023. The lower count for 2024 reflects the reporting lag at the time of data extraction rather than firms leaving the sample. This is due to the inclusion of environmental disclosure in the database, which required progressive updates. The sectoral distribution is stable across the expansion. This indicates that the growth in coverage is broad-based rather than concentrated in particular industries.

The dependent variable in this study is financial performance, measured by Return on Assets (ROA). It describes the firm's ability to operationalize its assets and produce returns on them. Return on Assets is widely used in sustainability research to represent firm financial performance (Febrianto & Nabila, 2025; Sirbu & Chirilov, 2025). The independent variables for this study are environmental strategies, measured by several indicators: energy-efficiency policy, emissions reduction, and environmental supply chain management. These three independent variables are measured by a dummy variable indicating whether a firm has the policy (1) or not (0). The binary coding is constructed using

Bloomberg's criterion for the presence of the policy at the firm during the observed period. This binary measurement thus follows Bloomberg's methodology for the policy indicator and is retained in the study. The Bloomberg fields for each environmental policy are: ENERGY_EFFICIENCY_POLICY, EMISSION_POLICY, and ENVIRONMENTAL_SUPPLY_MGT. The Bloomberg field definitions for each variable are as follows. Energy efficiency policy refers to a company's operational commitment to reduce energy waste in its disclosure. Emission policy refers to whether a firm has formal, documented policies for monitoring, reporting, and reducing its greenhouse gas and pollutant emissions. Environmental supply chain management refers to an indicator of whether the company has implemented formal policies toward minimizing environmental impacts within its supply chain. A value of one therefore indicates a formally adopted policy as disclosed by the firm and recorded by Bloomberg. However, it does not denote independently verified implementation, nor does it convey the quality of the policy. The policy indicators are used as reported by Bloomberg and are not independently validated against the firm's annual or sustainability reports. Then, the moderating variable in this study is board gender diversity, measured by the interaction between environmental strategies and the percentage of women on the board. Finally, the control variables for this research are board size, measured by the total number of board members; board meetings, measured by the number of board meetings throughout the year; firm size, measured by the natural logarithm of market capitalization; financial leverage, measured by the ratio of total liabilities to total assets; and crisis period, measured by the α dummy variable capturing the COVID-19 period.

This study employs a panel regression model with random effects to test the hypothesis. The regression models for this study are:

$$ROA_{it} = \beta_0 + \beta_1 EEP_{it} + \beta_2 (EEP_{it} \times BD_{it}) + \beta_3 ER_{it} + \beta_4 (ER_{it} \times BD_{it}) + \beta_5 ESCM_{it} + \beta_6 (ESCM_{it} \times BD_{it}) + \beta_7 BD_{it} + \beta_8 BS_{it} + \beta_9 BM_{it} + \beta_{10} MC_{it} + \beta_{11} FL_{it} + \beta_{12} CP_{it} + \epsilon_{it} \quad (1)$$

Where:

ROA_{it} : Represents return on assets

EEP_{it} : Energy efficiency policy of the firm

ER_{it} : Emission reduction

$ESCM_{it}$: Environmental supply chain management

BD_{it} : Board Diversity

BS_{it} : Board Size

BM_{it} : Board Meetings

MC_{it} : Market Capitalization

FL_{it} : Financial Leverage

CP_{it} : Crisis Period

ϵ_{it} : Error Term

This study employs a single interactive regression model that simultaneously incorporates both the direct effects of environmental strategies and their moderated effects through board diversity. This approach is theoretically and methodologically justified in several grounds. Theoretically, the research question of this study, "Do Environmental Strategy Policies Improve Financial Performance? The Moderating Role of Board Gender Diversity", inherently presupposes that the relationship between environmental strategies and financial performance is not uniform across all firms, but rather conditional upon the governance context. In this study, the context is the role of women on the board. As Dunk (2003) states, the variable to be used in the regression must be strongly supported by theory to justify its proposed role. Methodologically, the inclusion of interaction terms in a single regression model is consistent with the recommendation of Burks et al. (2019), who argue that "including an interaction term provides richer insights than is possible from a linear-additive model". In other words, a

model that excludes the interaction terms would only be able to estimate the unconditional effect of environmental strategies on ROA, thereby masking the systematic variation in this relationship. The interactive model thus enables a more nuanced and theoretically appropriate test of the study's hypotheses.

The empirical test is employed through several steps. Firstly, descriptive statistics are used to examine the distribution of the data and the characteristics of the variables. Next, the diagnostic test is performed to assess the data quality. A multicollinearity test is performed to make sure the independent variables are not highly correlated with one another. The model is estimated using random-effects GLS with Huber-White standard errors clustered at the firm level, which accommodates both heteroskedasticity and residual correlation within firms across years. The estimation comprises 200 clusters. Year fixed effects were also considered. A joint test of the annual indicators is statistically significant, $\chi^2(9) = 34.92$, $p < 0.001$. So, a specification including year fixed effects is reported alongside the primary model in Table 9. The crisis-period dummy is retained in the primary model since it isolates the single macro shock of theoretical interest in this window, while the year effect in Table 9 absorbs annual

Table 1. Sample Selection and Composition

Panel A: Sample distribution of the initial population and final sample per year

Year	Initial Population, <i>n</i>	Final Sample, <i>n</i>
2015	1,011	67
2016	1,011	72
2017	1,011	84
2018	1,011	89
2019	1,011	93
2020	1,011	96
2021	1,011	183
2022	1,011	186
2023	1,011	192
2024	1,011	143
Total firm-year observations	10,110	1,205
Unique firms	1,011	200

Table 2. Sample Composition

Panel B: Sample Composition by GICS Sector

GICS code	Sector	Firms	%	Firm-years	%
40	Financials	42	21.0	238	19.8
15	Materials	33	16.5	199	16.5
30	Consumer Staples	32	16.0	197	16.3
10	Energy	19	9.5	114	9.5
60	Real Estate	18	9.0	109	9.0
25	Consumer Discretionary	17	8.5	89	7.4
20	Industrials	15	7.5	96	8.0
50	Communication Services	13	6.5	102	8.5
35	Health Care	7	3.5	43	3.6
55	Utilities	3	1.5	14	1.2
45	Information Technology	1	0.5	4	0.3
	Total	200	100.0	1,205	100.0

Source: Data Processed

variation more generally. The substantive conclusions are identical under both treatments. Then, a Hausman test is performed to determine whether a fixed- or random-effects model should be used. A regression analysis is performed to analyze the main and interaction effects. Finally, three additional analyses assess the robustness of the estimates. First, the model is examined with year fixed effects and with industry fixed effects, both of which are significant ($\chi^2(9) = 34.92$, $p < 0.001$ and $\chi^2(10) = 69.41$, $p < 0.001$, respectively). This is done to address the possibility that unobserved temporal or sectoral factors drive the association. Second, the environmental policy variables and the moderator are lagged by one year, so that the explanatory variables predate the measurement of financial performance and contemporaneous reverse causality cannot account for the association.

Result and Discussion

Table 3 presents the descriptive statistics for all variables across 1,205 firm-year observations from 200 Indonesia companies. The dependent variable, ROA, records a mean of 5.169 (standard deviation 9.309), with values ranging from -93.522 to 68.30, reflecting considerable variation in financial performance across sampled firms. Among the three environmental strategies variables, energy efficiency policy is the most widely adopted, with a mean of 0.828, followed by emission reduction at 0.710, while environmental supply

management records the lowest adoption rate with a mean of 0.306. This low rate indicates that embedding environmental practices into supply chain operations remains relatively uncommon among Indonesian listed companies. The moderating variable, percentage of women on the board, averages 11.67 percent, suggesting that female board representation remains limited on average, consistent with the broader pattern of constrained board gender diversity in Indonesian corporate governance context. The control variables of governance show that sampled firms average 5.34 board members, with 9.5 board meetings per year.

Table 4 reports the pairwise correlation matrix of all the variables in the study. At the bivariate level, energy efficiency policy ($r=0.021$, $p\text{-value}=0.473$) and emission reduction ($r=0.028$, $p\text{-value}=0.337$) both show positive but statistically insignificant correlation with ROA, while environmental supply chain management records a small but significant positive correlation ($r=0.069$, $p\text{-value}=0.016$). As a moderating variable, the percentage of women on the boards shows an insignificant correlation with ROA ($r=-0.002$, $p\text{-value}=0.948$).

Table 5 reports the results of the multicollinearity test. All the VIF values fall below 10. The model used to calculate the VIF values excludes the interaction terms. Collinearity between a product term and its constituents is non-essential. It might alter the lower-order coefficients, but leaves the highest-order interaction coefficient, the standard error, model fit, and power to detect moderation unchanged (Dalal & Zickar, 2012; Echambadi & Hess, 2007). Thus, it can be concluded that these variables are free from multicollinearity. Consequently, the

Table 3. Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Return on Assets (ROA)	1,205	5.169	9.309	-93.522	68.300
Energy Efficiency Policy	1,205	0.828	0.377	0.000	1.000
Emission Reduction	1,205	0.710	0.454	0.000	1.000
Environmental Supply Mgt.	1,205	0.306	0.461	0.000	1.000
Women on Board (%)	1,205	11.668	15.848	0.000	100.000
Board Size	1,205	5.344	2.046	2.000	17.000
Board Meetings per Year	1,205	9.520	8.357	1.000	63.000
Crisis Year	1,205	0.386	0.487	0.000	1.000
In (Market Capitalisation)	1,205	30.277	1.806	20.600	34.715
Financial Leverage	1,205	3.374	2.798	0.856	30.913

Source: Data Processed

Table 4. Correlation

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
(1) Return on Assets (ROA)	1.000									
(2) Energy Efficiency Policy	0.021	1.000								
(3) Emission Reduction	0.028	0.577***	1.000							
(4) Environmental Supply Mgt.	0.069**	0.250***	0.317***	1.000						
(5) Women on Board (%)	-0.002	-0.017	-0.016	-0.046	1.000					
(6) Board Size	-0.054*	0.144***	0.202***	0.235***	0.098***	1.000				
(7) Board Meetings per Year	-0.086***	0.142***	0.114***	0.037	0.116***	0.242***	1.000			
(8) Crisis Year	-0.016	0.103***	0.036	-0.013	-0.006	0.081***	-0.026	1.000		
(9) In (Market Capitalisation)	0.218***	0.170***	0.138***	0.111***	-0.003	0.312***	0.243***	0.071**	1.000	
(10) Financial Leverage	-0.254***	0.045	0.009	-0.046	-0.020	0.092***	0.377***	0.050*	0.023	1.000

Source: Data Processed

main effect test can proceed.

Table 6 elaborates the model specification selection. The result show that for each model tested, the p-value exceed 0.05, which means that the random effect panel model is more appropriate to be used for this study. Therefore, random-effect panel model is used as the panel model for this study.

Table 7 provides the empirical results for the model tested in this study. The probability value of the model is significant ($\text{Prob} > \chi^2 = 0.000$) at the 1% level. This means that the explanatory variables are simultaneously significant in explaining the variation in the Return on Assets (ROA). The overall R^2 of 0.110 indicates that 11% of the variation in ROA can be explained by the explanatory variables. The within R^2 indicates that the model explains 9% of the variation within firms over time, while the between R^2 indicates that the cross-sectional variation between firms is explained by the model.

Energy efficiency policy, role of women on board, and firm's financial performance

The empirical results of this study reveal a positive and significant effect of energy efficiency policy on firm financial performance as measured by ROA, with a coefficient of 2.246 ($p\text{-value}=0.013$), thereby providing statistical support for H1, which means that energy efficiency policy influences ROA. This findings suggests that firms operating under energy efficiency policy frameworks experience meaningful improvements in asset profitability through at least two mutually reinforcing pathways. Several insights can possibly explain this result. First, when firms increase their energy efficiency in response to policy mandates, they experience reductions in energy expenditure and improvements in operational efficiency, both of which directly enhance profitability. Second, energy efficiency policy, by virtue of its long-term orientation, stimulates firm-level innovation in energy-saving technologies and processes, creating additional channels through which policy compliance translates into superior financial outcomes beyond mere cost reduction. A well-designed energy efficiency policy therefore improves financial performance not only by efficiently managing current resources use but also by promoting the innovative capacity that generates sustained competitive advantage over time.

The model fit statistics are presented in Table 8. This interpretation aligns with the findings of Caragliu (2021) who demonstrated that energy efficiency policy yields positive and significant association with productivity and profitability. In addition, Lui et al. (2021) showed that institutional adoption of energy-efficient systems generates higher return on assets. Collectively, these findings reinforce the conclusion that energy efficiency policy stimulates strategy that enhances profitability through operational efficiency gains, innovation-

driven advantage, and efficient managerial resource allocation. Contrary to the expectation of H4, however, the results reveal that the percentage of women on the board exerts a negative and significant moderating effect on the positive relationship between energy efficiency policy and firm financial performance, with an interaction coefficient of -0.140 ($p\text{-value}=0.003$). This finding indicates that as female board representation increases, the financial returns generated through energy efficiency policy are systematically attenuated, suggesting that board gender diversity, under certain conditions, weakens rather than amplifies the effect.

Several possible explanations can elaborate this result. A more gender-diverse board leads to more extensive monitoring, which delays the payoff of energy-efficiency investments and extends the approval of capital projects. Aureli & Brighi (2025) showed that greater gender diversity in boards is associated with more prudent but less immediately profitable decisions. In the context of energy efficiency policy implementation, the heightened cautioned exercised by gender-diverse boards might slow the pace of implementation thus deferring the financial payoff of policy compliance. This finding is in line with the study conducted by Orazalin & Baydauletov (2020). They also found the negative moderating effect of board gender diversity.

Table 5. VIF Result

Variable	VIF	1/VIF
Emission Reduction	1.595	0.627
Energy Efficiency Policy	1.558	0.642
Board Meetings per Year	1.304	0.767
Board Size	1.227	0.815
Financial Leverage	1.184	0.844
ln (Market Capitalisation)	1.175	0.851
Environmental Supply Mgt.	1.167	0.857
Crisis Year	1.029	0.972
Women on Board (%)	1.023	0.977
Mean VIF	1.252	—

Source: Data Processed

Table 6. Hausman Test

Specification Test	Model 1	Model 2	Model 3
Chi-square (χ^2) value	10.795	11.603	8.458
p-value	0.374	0.313	0.584
Selected model	Random Effects	Random Effects	Random Effects

Source: Data processed

Table 7. Panel Regression Result

Variable	Coef.	Std. Err.	z-value	p-value	95% Conf. Interval
Energy Efficiency Policy	2.246**	0.905	2.48	0.013	[0.472, 4.020]
Women on Board (%)	0.102**	0.042	2.41	0.016	[0.019, 0.185]
Energy Efficiency Policy $\times$ Women on Board (%)	-0.140***	0.048	-2.94	0.003	[-0.233, -0.047]
Emission Reduction	-1.322**	0.576	-2.29	0.022	[-2.452, -0.192]
Emission Reduction $\times$ Women on Board (%)	0.006	0.029	0.22	0.827	[-0.050, 0.063]
Environmental Supply Mgt.	-1.512*	0.911	-1.66	0.097	[-3.298, 0.274]
Environmental Supply Mgt. $\times$ Women on Board (%)	0.101**	0.044	2.30	0.021	[0.015, 0.186]
Board Size	-0.457	0.290	-1.58	0.115	[-1.026, 0.111]
Board Meetings per Year	0.012	0.031	0.37	0.711	[-0.050, 0.073]
Crisis Year	0.218	0.487	0.45	0.654	[-0.737, 1.173]
ln (Market Capitalisation)	1.735***	0.378	4.59	0.000	[0.995, 2.475]
Financial Leverage	-0.654***	0.230	-2.84	0.005	[-1.105, -0.202]
Constant	-43.598***	11.240	-3.88	0.000	[-65.627, -21.568]

Emission reduction, role of women on board, and firm's financial performance

The empirical results of this study reveal a significant effect of emission reduction on firm financial performance, with a coefficient of -1.322 (p-value = 0.022), thus supporting H2, which means that emission reduction influences financial performance negatively. This outcome implies that the financial obligations arising from emission reduction efforts exceed the benefits generated during the study period, resulting in a measurable contraction of asset-based returns. Several possible causes can be used to explain this result. The primary driver of this outcome might be explained by the structural disruption such as replacement of existing supply arrangements, investment in unfamiliar technological systems, or discontinuation of established business practices so that firm could accommodate the reduction (P. Fan et al., 2023).

In addition, low-carbon technologies tend to require more capital and take longer to generate returns compared to

conventional alternatives (Altunbas et al., 2022). Firms in carbon-intensive sectors experience hardest financial burdens because emission reduction demands more fundamental operational changes and larger resources commitments. This in turn squeezes near-term profitability (Provaty et al., 2024). Moreover, capital invested in decarbonization tends to crowd out spending on productive activities that drive earnings growth and the rising capital costs of emission reduction erodes short-term operational efficiency,

Table 8. Model fit statistics

Number of observations	1,205	Mean dependent var.	5.169
Wald χ^2	47.198	SD dependent var.	9.309
Prob > χ^2	0.000	Overall R ²	0.110
R ² (within)	0.090	R ² (between)	0.106

Source: Data Processed

Table 9. Specification and Robustness Checks

Predictor	(1) As reported	(2) + Year FE	(3) + Industry FE	(4) + Both	(5) One-year lag	(6) Excl. financials
Energy efficiency policy	2.246** (0.905)	2.461*** (0.929)	2.254** (0.915)	2.418** (0.943)	1.731 (1.105)	2.616** (1.114)
Women on board (%)	0.102** (0.042)	0.100** (0.040)	0.110*** (0.042)	0.107*** (0.040)	0.075 (0.053)	0.107** (0.052)
Energy efficiency × Women	-0.140*** (0.048)	-0.131*** (0.047)	-0.142*** (0.048)	-0.133*** (0.047)	-0.109* (0.058)	-0.141*** (0.053)
Emission reduction	-1.322** (0.576)	-1.157* (0.614)	-1.459** (0.585)	-1.326** (0.621)	-1.488** (0.633)	-1.875*** (0.695)
Emission reduction × Women	0.006 (0.029)	-0.004 (0.028)	0.007 (0.029)	-0.003 (0.029)	0.020 (0.037)	-0.011 (0.033)
Environmental supply chain mgt.	-1.512* (0.911)	-1.310 (0.963)	-1.731* (0.895)	-1.578* (0.939)	-1.089 (0.986)	-2.068* (1.095)
Env. supply chain × Women	0.101** (0.044)	0.094** (0.042)	0.096** (0.044)	0.089** (0.043)	0.059 (0.052)	0.135*** (0.051)
Board size	-0.457 (0.290)	-0.511* (0.287)	-0.439 (0.281)	-0.491* (0.277)	-0.455 (0.285)	-0.562 (0.363)
Board meetings per year	0.012 (0.031)	0.018 (0.033)	0.029 (0.027)	0.033 (0.029)	-0.002 (0.035)	0.014 (0.043)
Crisis year	0.218 (0.487)	—	0.246 (0.494)	—	0.117 (0.471)	0.357 (0.585)
In (Market capitalisation)	1.735*** (0.378)	1.759*** (0.385)	1.735*** (0.377)	1.758*** (0.385)	1.668*** (0.414)	2.170*** (0.503)
Financial leverage	-0.654*** (0.230)	-0.648*** (0.224)	-0.579** (0.232)	-0.577** (0.226)	-0.609*** (0.231)	-0.636** (0.264)
Constant	-43.598*** (11.240)	-44.178*** (11.360)	-38.272*** (11.828)	-38.978*** (11.964)	-41.165*** (12.147)	-55.155*** (15.163)
Year fixed effects	No	Yes	No	Yes	No	No
Industry fixed effects	No	No	Yes	Yes	No	No
Observations	1,205	1,205	1,205	1,205	1,043	967
Firms	200	200	200	200	200	158
Wald χ^2	47.20	98.59	1,186.03	1,284.77	40.60	49.08
R ² (overall)	.110	.123	.185	.196	.099	.113

Note: The dataset includes N = 1,205 firm-year observations from 200 firms, spanning 2015 to 2024. All models employ random-effects GLS, with standard errors clustered at the firm level, reported in parentheses. Column 1 reproduces the model from Table 7. In column 5, environmental policy variables and the moderator are lagged by one year, reducing the sample size to 1,043 observations. The crisis-year dummy variable is captured by the year indicators in Columns 2 and 4. Significance levels are indicated as: * p < 0.10, ** p < 0.05, *** p < 0.01.

Source: Data Processed

thus reducing short-term profitability (J. Huang et al., 2025; W. Lu et al., 2025).

From agency theory perspective, managers naturally resist action that reduce short-term profits. Since emission reduction falls into this category, firms pursue it only when pushed by external forces such as regulation or stakeholder pressure rather than out of financial self-interest (P. Fan et al., 2023). This in turn creates an issue in resource allocation often described as short-term productivity paradox of decarbonization where the costs of going green pile up before the benefits arrive, temporarily dragging down financial performance.

The results of H5, moderating role of women on the board, show an interaction coefficient of 0.006 ($p=0.827$), confirming that board gender diversity has no significant effect on the relationship between emission reduction and financial performance. This result may be attributed to the scope of board oversight rather than director characteristics. Expenditure on emission reductions is primarily driven by external factors, such as regulatory requirements and stakeholder pressure. As a result, the board's discretion to influence this spending is limited. A previous study shows similar patterns, suggesting that governance composition has a greater impact on environmental outcomes than on the short-term financial effects of externally mandated spending (Pathirana et al., 2025). Therefore, this explanation explains the insignificant moderating effect of the role of women. This result is in line with Nepal et al. (2025) who also found the non-significant moderation of board gender diversity on firm performance.

Environmental supply chain management and firm's financial performance

The empirical results of this study provide a marginal significant support of environmental supply management on firm financial performance at 10% level, with a coefficient of -1.512 ($p\text{-value}=0.097$). This result indicates that environmental supply chain management activities weaken firms' financial performance. This result supports H3 marginally, which means that environmental supply chain management influences financial performance. Several possible explanations can elaborate this result. Moreover, this outcome suggests that the cost burdens imposed by environmental supply chain practices outweigh their strategic and operational benefits during the period of study. Eventually, this leads to reduction in firms' profitability.

This finding is in line with Hoa et al. (2025) whose study finds that as firm expands its environmental supply chain management activities, the additional practices escalate the cost while at the same time causing a diminished financial returns. Furthermore, Lawati et al. (2024) show that environmental supply chain management activities do not always translate gains for the company, but rather imposing additional burdens that constrain profitability. The negative financial effect is further accumulated when firms have to extend environmental oversight across the supply chain (Qi & Hu, 2021).

From agency theory perspective, the negative financial effect of environmental supply chain management activities could be understood as a consequence of externally driven cost obligation that compete with internal value-creation investment (Alexopoulos et al., 2018). When firms are compelled to abide by regulatory requirements, buyer demands, or stakeholder expectations to adopt comprehensive environmental supply chain practices, the resource might be allocated from a productive investment that might directly enhance firms' profitability.

However, the findings further show that this negative financial effect is moderated by the presence of women on

the board with a positive and significant coefficient of 0.101 ($p\text{-value}=0.021$). These findings indicate that higher female board representation meaningfully weakens the negative relationship between environmental supply chain management activities and financial performance. This indicates that having women on the board is associated with a stronger link between environmental supply chain management and financial performance, possibly due to the monitoring and oversight mechanisms described earlier. This positive moderating effect is consistent with the study of (Benjamin et al., 2020). They conclude that female directors demonstrate particularly strong capacities for oversight and strategic guidance in sustainability-related governance. Lu et al. (2025) argue that women bring distinctive monitoring capabilities that enable firms to extract greater efficiency and strategic value from environmental supply chain management activities while carrying the cost burdens.

Table 9 reports the specification and robustness checks. Columns 2 to 4 add year fixed effects, industry fixed effects, and both effects. Energy efficiency policy remains positively associated with Return on Assets. Emission reduction remains negatively associated, and environmental supply chain management remains marginally negative. The interactions with board gender diversity also persist for each interaction. Column 5 lags all environmental policy and the moderator by one year, reducing the sample to 1,043 firm-year observations. The emission reduction association is unchanged, while the energy efficiency and supply chain coefficients lose their significance. This means that these two associations are contemporaneous rather than lagged. Column 6 reports the result when financial sector firms are excluded. The results show that all associations strengthen. Therefore, the baseline results from the primary model are not sensitive to the variance estimator, temporal or sectoral controls, with the exception of energy efficiency and supply chain management associations, since they are sensitive to lagging.

Conclusion

This study investigates the financial performance implications of three environmental strategies, i.e energy efficiency policy, emission reduction, and environmental supply chain management, and the moderating role of women on the board. Anchored in agency theory, the study seeks to establish whether environmental strategy adoption translates into measurable financial gains or losses, and whether the presence of women on boards meaningfully alters these relationships. The findings collectively reveal that the financial consequences of environmental engagement are strategy-specific rather than uniform. In addition, the influence of women on boards operates selectively depending on the type of environmental strategy under consideration. This therefore offers a nuanced contribution to both the environmental governance and corporate finance literatures within an emerging market context.

Regarding the direct association of environmental strategies with firm financial performance, the results yield a mixed but theoretically coherent picture. Energy efficiency policy is the only environmental strategy found to be positively and significantly associated with ROA. A possible interpretation, which is consistent with prior literature, is that reduced operational costs and improved energy productivity underlie this association, although neither of them is directly examined in this study. This finding aligns with the agency theory argument that energy efficiency policy functions as an external governance mechanism that might be associated with the increase in ROA. In contrast, both emission reduction and environmental supply chain management are negatively associated with financial performance. Emission reduction is negatively and significantly associated with ROA. This pattern is consistent with the short-

term financial burden of capital-intensive decarbonization investment, although this mechanism is not directly examined in this study. Likewise, environmental supply chain management is marginally associated with lower ROA at the 10% level. A possible interpretation is that compliance and monitoring costs associated with environmental supply chain management reduce profitability, although the cost channel is not observed in this study.

With respect to the moderating role of women on the board, the findings present a differentiated and theoretically instructive pattern across the three environmental strategies. Women on boards negatively and significantly moderate the positive relationship between energy efficiency policy and financial performance. This suggests that more extensive board monitoring is associated with a slower conversion of energy efficiency policy adoption into immediate profitability gains. In the emission reduction context, the moderating role of women on boards is insignificant, indicating that the proportion of women on the board cannot offset or amplify the financial consequences in the sampled firms. However, women on boards positively and significantly moderate the negative relationship between environmental supply chain management and financial performance. This is consistent with more extensive board oversight being associated with better containment of the cost burdens arising from supply chain management, although director-level behaviour is not observed in this study.

The findings of this study have theoretical and practical implications. Theoretically, this study advances the understanding of how environmental strategy type and board gender composition jointly shape firm financial performance in an emerging market setting. It demonstrates that agency theory provides a coherent but context-sensitive framework for interpreting these relationships. The results challenge the assumption that environmental strategies are uniformly beneficial or detrimental to financial performance. Similarly, these results challenge the assumption that women on boards universally enhance the financial performance of environmental engagement.

Practically, energy-efficiency policy has the strongest significant positive contemporaneous association with ROA, but this relationship is not causal or sustained in lagged analysis. On the other hand, these firms must approach emission reduction and environmental supply chain management as long-term strategic investments while managing the short-term costs effectively. The finding that women on the board are particularly effective in moderating the financial cost of environmental supply chain management encourages their presence in the boardroom. Future research should extend these findings by examining the long-term financial effects of environmental strategies and exploring cross-industry heterogeneity. Moreover, investigation of how Indonesia's specific regulatory, cultural, and institutional environment shapes the governance uncovered in this study demands further examination.

This study is linked to several limitations. First, the research design is observational, and the estimates are exposed to endogeneity problems that can arise from several sources, such as reverse causality, which is not examined in this study. Furthermore, although the random effect specification with robust standard errors is applied, it does not eliminate the endogeneity potential arising from reverse causality or omitted variables. This study also omits several variables that can influence the relationship between environmental policies and financial performance, such as ownership concentration, capital intensity, and capital expenditure. The sample consists of unbalanced data from 200 firms and cross-industry data, which may also cause limitations in the generalisability of the results. A further limitation is related to selection into the observed sample. Sample inclusion required the simultaneous availability of Bloomberg environmental policy, return on assets, and board gender data. This means the 200 retained firms have more complete ESG data coverage. Since the coverage is closely associated with firm size and analyst attention, the sample skews toward larger and more visible issuers. The findings are therefore generalized to larger and better covered Indonesian firms rather than the full population, and the moderation effects may differ among smaller or less disclosing firms. Then, the environmental strategy is measured using a binary variable indicating whether the firm has the policy. This study does not measure policy performance or its implementation. Then, financial performance is measured by a single accounting ratio: ROA. Furthermore, the lagged specification reported in Table 9 further indicates that the energy efficiency and supply chain associations are contemporaneous rather than persistent. This means that these estimations need to be read as short-run associations within the observation rather than as evidence of a delayed financial payoff. Future study may address the data-availability selection directly, such as matching covered firms with comparable firms lacking Bloomberg coverage. Future studies can use GMM estimation to tackle the endogeneity problem that can occur. Future studies can also explore the degree of implementation of the policy. Several proxies can also be used to measure financial performance.

Author contributions

The first author contributes in the following aspects: Conceptualization, methodology, formal analysis, investigation, data curation, writing-original draft, writing – review and editing, project administration. The second author contributes in the following aspects: Conceptualization, methodology, formal analysis, investigation, writing-original draft, project administration, supervision.

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