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Environmental Innovation and Firm Performance in ASEAN-5 Countries: The Role of Board Tenure and Board Gender Diversity

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Abstract

Purposes: This study seeks to assess impacts of environmental innovation on firm performance through a sustainability lens in the ASEAN-5 member states. This study analyzes the effects of environmental initiatives on financial performance as well as the moderating effects of board length and board gender diversity on this nexus.

Methods: This research utilizes panel data from Refinitiv Eikon for the years 2019-2025 along with sustainability reports and employs panel regression. To assess the reliability of results, quadratic tests and robustness tests are employed. Firm performance is assessed through two main indicators: Tobin's Q and ROA.

Findings: As a result of this study, environmental innovation, especially in the case of innovation in circular activities, such as waste management, positively impacts financial and market performance. This study has also shown that board tenure does not have a moderating impact. In contrast, board gender diversity has a positive, moderating impact once the critical mass of women on the board has been reached.

Novelty: This study seeks to merge board tenure and board gender diversity in the sustainability and corporate governance integration in the ASEAN-5 countries. Unlike predecessors that examined the impacts in isolation, this study analyzes board composition as a key governance element in the context of environmental innovation and performance of environmental innovation efforts.

Keywords: Board Gender Diversity, Board Tenure, Corporate Governance, Environmental Innovation, ESG, Firm Performance

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INTRODUCTION

Performance of a firm is more than just attaining superior financial outcomes. It is insufficient to measure a firm's overall condition by just profit-based metrics. Firms unable to create a competitive advantage or fail to operate profitably and sustain a continuous basis are generally difficult to survive in today's unpredictable and fast-changing business environment. Performance is more and more being evaluated in conjunction with non-financial information. One area of growth that has attracted attention, ironically, is responsiveness to growing sustainability challenges and stakeholder pressures in global markets irrespective of the firm's reputation and performance; in other words, overall resilience and flexibility.

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Environmental challenges can greatly impact businesses operationally, regulatorily, and reputationally. In the modern day, one cannot ignore climate change anymore. Firms who do not respond to the changing environmental demand will face tougher regulations, changing consumer demand and pressure from sustainability-minded investors. In the case of the ASEAN-5 which include Indonesia, Malaysia, Singapore, Thailand, and The Philippines, the ASEAN Green Deal, the ASEAN Sustainable Finance Taxonomy, and the Sustainable Development Goals (SDGs) are connected in this way. Many companies in the ASEAN region are early in their sustainability journey causing uncertainty on how initiatives to protect the environment will impact firm performance.

The basis of the study rests on agency theory and legitimacy theory. Legitimacy theory explains that the actions of a business cannot be analyzed independent of the social expectations and standards of the society in which the business operates. Agency theory considers socially responsible actions as a form of governance which helps safeguard the interests of the shareholders and stakeholders of the business. Firms that do not gain social acceptance will face challenges in sustaining their operations and securing access to critical resources. Firms will not be able to ignore the environmentally socially responsible practices that contribute to the firm's efforts to meet stakeholder expectations. Agency theory views socially responsible activities as a governance practice that safeguards the interests of the firm's stakeholders. Without effective governance, sustainability-related investments might not contribute to economic value and might only achieve nominal compliance.

In these circumstances, a firm's response to evolving environmental concerns through the management of their competitive position cannot disregard the environmental strategies that the firm employs. Overlooking environmental innovation may bring additional challenges to a firm in managing its impacts on the environment and in the effective management of the firm's resources. Certainly, innovation in a firm's environmentally constructive goods, services, and business practices is essential for supporting the firm's long-term viability and profitability (Flachenecker et al., 2022; Kemp et al., 2019).

Firms that do not engage environmental innovation may face challenges in managing the costs of their business operations, impacting the efficiency of their business, and meeting the demands of the environmentally conscious markets. On top of this, environmental innovation is important to address the firm's loss of legitimacy and reputation among the firm's stakeholders (Babiker et al., 2025). Environmental innovation is not only a response to the concerns of sustainability, but also a way for firms to elevate the efficiency of their operations and improve their competitive position. Therefore, sustainability of the firm is not the only measure of success, but is the firm's ability to establish and sustain a long-term competitive position in the marketplace (Di Simone et al., 2022; Khalil et al., 2024). Mac Lennan et al. (2023) emphasize the role of environmental innovation as a response mechanism to serve the needs of the marketplace and as a means to establish a competitive advantage for the firm.

Many studies have examined the connection between green innovations and organizational performance. Some studies suggest green innovations are capable of creating operational efficiencies and cost containment while providing sustainable competitive advantage (Doran & Ryan, 2012; Hojnik & Ruzzier, 2016; Horbach et al., 2012). Some studies suggest green innovations are able to improve corporate image and increase competitive advantage in the marketplace (Bai et al., 2020; Barriga Medina et al., 2022; Chassagnon & Haned, 2015; Farza et al., 2021; Iqbal et al., 2022). While it is clear there is an upside potential in the case of environmental innovations, the extent of variable results stemming from numerous studies in different contexts suggests the relationship is likely the result of a multitude of contextual considerations.

Environmental Innovation and Firm Performance

According to legitimacy theory, environmental innovations are a strategic response of firms to social pressures and stakeholder demands. By adopting such practices, firms signal

their commitment to sustainability and, in turn, strengthen their legitimacy while enhancing stakeholder trust and broadening their access to resources. Consequently, firm performance can be improved from both operational and market efficiency.

This argument is well grounded in research. As to the basis for execution, Thomas et al. (2021) and Russo et al. (2022) write that environmental innovation is the change in a company's products or processes that result in a less resource intensive and less air polluting renovation. Therefore, the company's impact on the outside world is less.

Numerous positive outcomes also result from such actions. Horbach et al. (2012) point out that innovations of such kinds improve the efficiency of processes, and Doran and Ryan (2012) show that innovations improve organizational financial performance. Hojnik and Ruzzier (2016) also make the case and show that green innovation improves competitiveness of an organization. This is the case in the research of Farza et al. (2021) and Iqbal et al. (2022), which show that innovations in the environmentally friendly space also create positive financial value.

Supporting this work, L. Liu (2024) showed that environmental innovation becomes vital in improving operational integrity and reducing a range of risks, all contributing to the enhancement of overall firm performance. On the basis of such theories and their accompanying rich empirical findings, environmental innovation is considered beneficial to firm performance. Thus, the first hypothesis was formulated.

H_1: Environmental innovation has a positive effect on firm performance in ASEAN-5 countries.

The Moderating Role of Board Tenure

The connection between environmental innovations and business performance differs across businesses, as it depends on certain internal governance mechanisms of the business (Sun & Bhuiyan, 2020). Board tenure is one of the critical governance mechanisms. Based on Agency Theory, it has been argued that long-tenured boards have higher monitoring capabilities due to their experiences and knowledge of the firm (Arslan et al., 2023; Ben-Amar et al., 2013; Hafsi & Turgut, 2013). Consequently, seasoned board members are better equipped to evaluate complex strategic initiatives like environmental innovation and oversee their effective implementation.

Livnat et al. (2021) argued that valuable advisory resources are provided by experienced board members, leading to improvements in the quality of decision making. Similarly, Sun and Bhuiyan (2020) suggested that a deeper understanding of firm operations and relationships with stakeholders is enhanced by longer board tenure. In addition, directors' attention to environmental issues may be influenced by board tenure, as greater experience and knowledge of the company's conditions are associated with longer tenure (Gallego-Álvarez & Rodriguez-Dominguez, 2025). Therefore, greater likelihood is observed for environmental innovation to be integrated into corporate strategy in a way that enhances firm performance when boards with longer tenure are involved.

Longer board tenures have also been associated with a lack of board independence and a lack of the ability to adapt to change (Khan et al., 2020; Wang et al., 2020). Such boards have a direct impact on firm performance (Fayyaz et al., 2025; Gavana et al., 2024) and will have an indirect impact in the success of environmental initiatives. Board tenure will add to the performance aids that a firm gains from environmental initiatives. With that in mind, we put forward the second hypothesis.

H_{2a}: Board tenure moderates the relationship between environmental innovation and firm performance.

The Moderating Role of Board Gender Diversity

Gender diversity in the boardroom is a significant governance framework. Agency theory suggests that a more diverse board means more firm specific and more context specific knowledge

and therefore more firm specific and more context specific knowledge (Carter et al., 2003; Hillman and Dalziel, 2003).

Greater sensitivity toward ethical, social, and environmental issues is also attributed to female directors (Mansour et al., 2024; Moreno-Ureba et al., 2022; Nadeem et al., 2020; Nuber & Velte, 2021; Post & Byron, 2015), thereby leading to an increased focus by the board on sustainability-related strategies. Under such conditions, environmental innovation can be adopted more substantively by firms and more effectively integrated into corporate strategy (Ayadi et al., 2025).

Previous empirical studies further demonstrate that gender diversity can improve firm performance through enhanced governance quality and reduced agency conflicts (Loh et al., 2022; Veltri et al., 2021). Moreover, Brahma et al. (2021), Saggese et al. (2021), and Islam et al. (2022) describe how a critical mass of female directors influences a company's performance. Gender diversity indicates stronger corporate strategies. When considering environmental innovation, it is assumed that board diversity will encourage the implementation and monitoring of sustainability strategies, increasing the chances of positive environmental innovation outcomes and improved performance. This is further supported by the findings of Wu et al. (2022), Almaqtari et al. (2024), and García Martín and Herrero (2020), who found that board gender diversity strengthens the link between sustainability strategies and firm performance. This brings us to the formation of the third hypothesis:

H_2b: Board gender diversity moderates the relationship between environmental innovation and firm performance.

Research Gap and Contribution

Even with the advancements in the analysis of environmental innovation and corporate governance, there remain key gaps. Firstly, prior research has focused primarily on environmental innovation's direct impact on firm performance, neglecting how governance mechanisms may act as moderating factors. Secondly, the evidence that is available predominantly comes from the developed world, reducing its applicability to the ASEAN-5 emerging markets. Environmental innovation combined with the characteristics of board members offers an exciting avenue to study the impact on firm performance in the ASEAN-5 countries, with their unique governance systems and fluctuating constraints of regulation and sustainability, and the growing demand for sustainability. This study aims to address the gaps by combining environmental innovation and corporate governance in emerging markets.

METHODS

Sample

This project looks at non-financial firms constituting the Association of Southeast Asian Nations' ASEAN-5 group (Indonesia, Malaysia, the Philippines, Singapore, and Thailand) from 2019 to 2025. Financial firms were intentionally excluded to maintain consistent data, as they operate under unique regulations and have negligible direct environmental impacts. In contrast, non-financial firms are critical for studying green innovation. They enable advanced research because of the pollution from the emissions and waste, and the extensive energy consumption. The objective in this case is to analyze the medium-term effects, specifically the effects in the pre-, post-, and in the pandemic (COVID-19) periods, and recent years completing the fully verified and published annual reports.

Using a purposive sampling technique allowed the researchers to make a final selection of 120 companies from an initial selection of 4,401 companies. Companies without full annual reports or without environmental innovation metrics on the Refinitiv Eikon platform were eliminated. Using this strategy, a strongly balanced panel dataset of 840 firm-year records was

constructed. A strongly balanced panel is an advantage because it provides an uninterrupted data stream for all the firms included in the study. This dataset is ideal for analyzing the effects of green innovation on the firms' corporate performance.

For objective and quantitative evaluations, the correct definition and measurement of variables is of utmost importance. The present study classified the variables in this paper as a dependent variable, independent variable, and, as it is popularly called, moderating, and control variables. The assessment of corporate performance (the dependent variable) was conducted using Tobin's Q. Tobin's Q, defined by the market value of equity and the book value of debt divided by total assets, reflects how the market perceives a firm's capacity for the generation of value.

In this research, the independent variable is the Environmental Innovation Score from Refinitiv Eikon. With a range from 0 to 100, the score reflects a firm's level of environmentally sustained innovative activities, investments in green, and environmentally focused research and development. Higher scores indicate a greater level of environmentally sustainable business practices and greater score transparency. In the research framework, Board Tenure and Board Gender Diversity are viewed as moderating variables. Board Tenure is measured by the average number of years served by Board members, while Board Gender Diversity is the percentage of females on the Board.

Control variables are included after establishing the core association to capture the association as a result of other performance drivers that may be present. These include the size (the natural log of total assets), financial leverage (the total debt to total assets ratio), and corporate growth (the annual sales growth). Other governance variables include board size (the total number of board members) and board independence (the total number of independent board members). Lastly, to capture the shocks and the effects of the macro economy, the country governance assessment from the Worldwide Governance Indicators (WGI) and a COVID-19 dummy variable, which assigns a value of 1 for the pandemic years and 0 for the other years, are incorporated.

Research model

This research aims to unpack the relationship between environmental innovation and organizational performance by examining panel data and the impact of environmental innovation using multiple linear regression. Building on this idea, we also employ Moderated Regression Analysis (MRA) to explore the moderating role of board tenure and board gender diversity on the primary relationship of interest.

The regression models employed in this study were developed by Souza et al. (2024) and Nurabiah et al. (2023). Model 1 is applied when testing Hypothesis 1 (H1) and captures the direct, stand-alone relationship between environmental innovation and the performance of the firm. Model 2 is applied when testing Hypotheses 2a (H2a) and 2b (H2b) and captures performance of the firm within the context of the moderating variables of board tenure and board gender diversity. The goal of having both models is to allow study participants to examine the relationships within the variables of the study as thoroughly and as rigorously as possible. In this case, Model 1 acts as the most basic and entry-level model and allows the study participants to see how environmental innovation directly impacts firm performance in the absence of any moderating variables. In contrast, Model 2 enables the study participants to see how the moderating variables impact the relationship of environmental innovation and firm performance. The addition of both models provides an analysis of the research in the context of sustainability and management constraints.

Model 1

$$TobinsQ_{it} = \beta 0 + \beta 1 EI_{it} + \beta 2 BT + \beta 3 BGD + \beta 4\ FirmSize_{it} + \beta 5 Lev_{it} + \beta 6 Growth_{it} + \beta 7 NumBoard_{it} + \beta 8 Bind_{it} + \beta 9\ WGI\_Agregate_{it} + \beta 10\ DummyCov_{it} + \varepsilon_{it} \quad \text{.....(1)}$$

Model 2

$$TobinsQit=\beta0+\beta1EIit+\beta2BTit+\beta3BGDit+\beta4(EIit\times BTit)+\beta5(EIit\times BGDit)+\beta6FirmSizeit+\beta7Levit + \beta8Growthit + \beta9NumBoardit + \beta10Bindit + \beta11\ WGI\_Agregateit + \beta12\ DummyCovit + \varepsilon it \quad (2)$$

Description:

TobinsQit	: Measured by Tobin's Q
EIit	: Calculated by the Environmental Innovation score
BTit	: Length of tenure in years
BGDit	: The percentage of female directors on the board
FirmSizeit	: Natural logarithm of Total Assets
Levit	: Total Liabilities divided by Total Assets
Growthit	: Total Sales Growth
NumBoardit	: The total number of members on the board
Bindit	: The proportion of independent directors on the board
WGI_Agregateit	: Average country-level governance score
DummyCovit	: Dummy Covid-19

RESULT

Descriptive Statistics

This project uses Tobin's Q to assess firm value. Tobin's Q is the dependent variable, while environmental innovation is the independent variable. Other variables are included in the study presented in Table 1, as discussed below:

Table 1. Descriptive Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
TobinsQ	840	1.533682	1.860035	0	16.21873
EIS	840	50.3258	24.13537	0	98.16754
BT	840	8.177159	4.890701	0	25.44444
BGD	840	0.177585	0.129129	0	0.714286
FirmSize	840	22.30733	1.630829	0	25.36635
Lev	840	0.5151115	0.177492	0	1.614748
Growth	840	-0.429981	1.842825	-35.78825	19.42601
NumBoard	840	9.741667	3.083839	0	20
BoardInd	840	14.12696	24.58557	0	100
WGI_Agregate	840	53.02965	27.90992	0	89.7
DummyCov	840	0.428572	0.495166	0	1

Source: Data Processed (2026)

From the descriptive statistics in Table 1, Tobin's Q had a mean value of 1.53 and standard deviation of 1.86. The data reveals a considerable deviation in the market value of a firm compared to the value of a firm's assets. There is also variation in the implementation of environmental innovation (EIS), as shown by a mean score of 50.33 (SD = 24.14). Concerning the other variables, board tenure (BT) had a mean of 8.18 years (SD = 4.89), and board gender diversity (BGD) indicated an 18% (0.18) female board.

The size of the firm (natural log of total assets) was 22.31, and average total leverage was moderate at 0.52. Total sales growth was low, showing a firm with a significant decline in sales,

at -35.79 (mean = -0.43). From a governance standpoint, the average total number of board members was 9.74 with an average of 14.13% of the board members being independent. Regarding governance control, the WGI Aggregate, has an average of 53.03 and 42.86% of the observational data were collected during the COVID-19 pandemic (2020-2022). The research sample shows a significant diversity of internal characteristics, governance, and environmental strategies. These factors as listed, may impact the innovation and firm performance relationship.

Regression Test

The data in Table 2 shows that the Environmental Innovation Score (EIS) is positively related to Firm Performance, measured by Tobin's Q, and the relationship is statistically significant (p-value = 0.045). The research hypothesis is, therefore, supported, and this study has found a positive relationship of environmental innovations to market performance. Board Tenure (BT) was not relevant in this context, as the relationship is negative, and is statistically insignificant (p-value = 0.263).

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Table 2. Regression test for Model 1

Variabel	Regression Model 1	
	Fixed Effect Model	
	t	Probability
Constant	5.55	0.000
EIS	2.01	0.045**
BT	-1.12	0.263
BGD	-2.51	0.012**
FirmSize	-4.40	0.000***
Lev	-1.04	0.298
Growth	2.53	0.012**
NumBoard	1.44	0.150
BoardInd	-2.05	0.041**
WGI_Agregate	-1.96	0.050*
DummyCov	2.28	0.023**
R-Square Within = 0.1091		
R-Square Between = 0.1443		
Prob > F = 0.0000		
Obs = 840		

Notes: significant level at * p<0.01, ** p<0.05, *** p<0.10

Source: Data Processed (2026)

The analysis of Model 2 (Table 3) suggests that the variability of company value (Tobin's Q) is poorly explained by the independent variables under consideration, as indicated by the within R-squared value of 12.02%. The F-test results show that the model is valid and significant ($p < 0.001$), however the T-test results are more nuanced. Environmental Innovation Score (EIS) and Board Tenure (BT) are both positively estimated, and both remain insignificant ($p = 0.226$ and 0.328, respectively). Therefore, the two variables are in this model substantively irrelevant to firm performance.

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Table 3. Regression test for Model 2

Variable	Regression Model 2	
	Fixed Effect Model	
	t	Probability
Constant	5.70	0.000
EIS	1.21	0.226
BT	0.98	0.328
EIS×BT	-1.90	0.058*
BGD	-3.47	0.001***
EIS×BGD	2.50	0.013**
FirmSize	-4.58	0.000***
Lev	-0.91	0.362
Growth	2.32	0.021**
NumBoard	1.56	0.119
BoardInd	-2.42	0.016**
WGI_Agregate	-2.22	0.027**
DummyCov	2.06	0.040**
R-Square Within = 0.1202		
R-Square Between = 0.1462		
Prob > F = 0.0000		
Obs = 840		

Notes: significant level at * p<0.01, ** p<0.05, *** p<0.10.

Source: Data Processed (2026)

In evaluating the interaction effects, the joint influence of EIS and BT (EIS×BT) was deemed to have a negative effect and to be of marginal significance ($p = 0.058$). Therefore, BT has a marginally negative and moderating effect of a small order on the link between Environmental Innovation and firm performance. On the other hand, the effect of Board Gender Diversity (BGD) was negative and bound to do act of a small order ($p = 0.001$). However, the combination of BGD and EIS (EIS×BGD) has a positive and significant effect ($p = 0.013$) and shows that BGD positively affects Environmental Innovation and firm performance. Hence, the results of Hypothesis 2a (and to the 10 percent significance level) have practically no relevance, while Hypothesis 2b is substantiated. The summary of the hypothesis result is shown in Table 4.

Table 4. Summary of Hypothesis Testing Result

Hypothesis	Description	Prediction	Result	P-Value	Decision
H1	Environmental innovation has a positive effect on firm performance	Positive	Positive	0.045	Supported
H2a	Board tenure moderates the relationship between environmental innovation and firm performance	Positive	Negative	0.058	Weakly Supported
H2b	Board gender diversity moderates the relationship between environmental innovation and firm performance	Positive	Positive	0.013	Supported

Source: Data Processed (2026)

Environmental Innovation and Firm Performance in ASEAN-5 Countries: Moderated by Board Tenure and Board Gender Diversity

Environmental innovation is now a fundamental element for sustainable business growth strategies in the ASEAN-5 region. In different ASEAN-5 countries, businesses are under greater global pressure to adopt environmentally friendly practices. According to Rennings (2000), innovations are defined as far-reaching changes of products, processes, or policies of firms aimed at effective protection of the environment. Further, the incorporation of green initiatives into the firm's business strategies combines the firm's rationality of a market-oriented business strategy and an opportunity to realize a sustainable competitive advantage (Porter & Van Der Linde, 1995).

The outcomes of this study demonstrate that the Environmental Innovation Score (EIS) has a positive, statistically significant effect on firm performance measured by Tobin's Q. This finding aligns with Horbach et al. (2012) in that green innovation affords higher levels of operational effectiveness and efficiency for firms. Environmental Innovation positively influences the Corporate Value of firms even in the ASEAN-5 where the level of uptake varies, particularly in fast growing markets with a focus on sustainability. The impact of environmental regulations and other supportive measures provided by the government on this relationship may also be significant (ASEAN Secretariat, 2021).

From the framework of corporate governance, there is interest in understanding the impact of board tenure on the quality of strategic decisions and the effectiveness of strategic decision oversight. However, the outcome of the regression analysis indicates that board tenure does not have a direct and significant impact on aggregate firm performance. The study also examines the impact of board tenure on the interaction between environmental innovation and firm performance. The study shows that board tenure has a negative, significant, and moderate impact on that interaction at the 10% significance level. The study indicates that the contribution of environmental innovation to corporate value is more pronounced in contexts where there is a lower concentration of long-serving directors. This can be explained using the entrenchment effect, where long-tenured directors become less flexible to new strategies, such as green innovation. This reflects the governance challenges of emerging markets as cited by Claessens and Yurtoglu (2013), where poor board performance is a consequence of weak investor protection and high ownership concentration.

Additionally, the importance of Board Gender Diversity (BGD) as an element of policy governance should not be overlooked. BGD showed a statistically significant moderating impact when testing the interaction of environmental innovation and firm performance. The positive interaction of the EIS and BGD suggests that the inclusion of women on boards can strengthen the relationship of environmental innovation and the firm's value. This indicates that gender-diverse boards not only provide a greater number of perspectives, but also tend to increase the quality of their decisions, as well as their concern for sustainability issues. Although the representation of women on boards in the ASEAN-5 is low, evidence suggests that gender diversity improves the effectiveness of environmental strategies.

In general, this research indicates that the internal governance of the firm significantly impacts the relationship of environmental innovation and firm performance. Increased board tenure may act as a negative constraint, while board gender diversity may act as a positive constraint, and thus enable the potential of green initiatives. For this reason, it is recommended that firms in developing countries, especially those in the ASEAN-5, create more inclusive and flexible boards in order to gain the most value from their sustainable business initiatives.

Additional Test

Alongside previous studies on governance (Claessens & Yurtoglu, 2013; Vafeas, 2003), our results indicate that Board Tenure (BT) does not directly affect firms' performance. This is indicative of the notion that the longer directors are retained, the better it is for the company. However, when BT is considered as a moderator, the interaction term (EIS×BT) shows a negative impact at the 10% significance level. Therefore, BT as a weak moderator reduces the positive effect that environmental innovation may have on the performance of the firm.

The previously mentioned studies hold that there is a linear relationship between board tenure and firm performance. It should therefore be stated that there is a possibility that this relationship is non-linear. Long tenured board members have several advantages, and this includes that they possess the firm specific knowledge and are in a position to provide better advice. However, board members with long tenures may also become entangled, less independent and more resistant to changes in firm strategy; thus, the board becomes less effective overall (Claessens & Yurtoglu, 2013). To measure this, we added a different test using the quadratic term (Board Tenure^2) to determine if the costs of longer board tenures outweigh the benefits of shorter board tenures. Adjusting for this is very important because only using a linear term may produce an incomplete model of a firm and its governance (Huang, 2013).

Board Gender Diversity (BGD) demonstrates a different trajectory. Data reveals a substantive and significant negative correlation between BGD and firm performance. Shifting BGD into a moderating position reveals a significant positive interaction (EIS×BGD). Consequently, boards that are more gender-diverse are more likely to foster or support environmental innovation. This is consistent with the gender-diversity literature, which posits that gender-diverse boards positively influence and improve the quality of board decisions. This also relates to and fosters sustainability (Joecks et al., 2013; Post & Byron, 2015).

However, most of these studies also indicate that the relationship of gender diversity to performance may also be non-linear (Joecks et al., 2013; Richard et al., 2004). Very small numbers of women on boards may result in women being token members with no real power to make decisions, while very large numbers of women on boards may result in conflicts or coordination problems. To address this issue, we examined a quadratic term BGD^2 to identify a diversity tipping point that is optimal for firm performance. By introducing quadratic terms for both constructs, this study captures the intricate nature of board design. This also extends the theory of corporate governance and the effectiveness of environmental innovations. This also adds the clarity and corporate governance context and theory (Huang, 2013; Joecks et al., 2013).

Table 5. Additional Test

Variable	Regression Model Fixed Effect Model	
	t	**Probability**
Constant	5.77	0.000
EIS	2.20	0.028**
BT	2.18	0.030**
EIS×BT	-2.10	0.036**
BT2	1.96	0.050**
EIS×BT2	1.64	0.101
BGD	-0.92	0.356
EIS×BGD	-0.28	0.779
BGD2	-1.25	0.211
EIS×BGD2	1.51	0.132
FirmSize	-4.76	0.000***
Lev	-1.05	0.294
Growth	2.31	0.021**
NumBoard	1.74	0.083*
BoardInd	-2.22	0.026**
WGI_Agregate	-.21	0.027**
DummyCov	2.07	0.039**
R-Square Within = 0.1287 R-Square Between = 0.1513 Prob > F = 0.0000 Obs = 840		

Notes: significant level at * p<0.01, ** p<0.05, *** p<0.10

Source: Data Processed (2026)

Table 5 presents findings from our quadratic analysis. In our study, the squared board tenure term (BT^2) shows a positive, marginally significant effect on firm performance (p = 0.050). We interpret this as an example of a non-linear relationship, where a positive coefficient means that the firm abstracts value from director tenure up to a limit. This limit may be reached when directors have enough firm-specific knowledge to become value neutral or detrimental to performance. Since this finding is only marginally significant, we interpret this finding with caution.

For the interaction term of environmental innovation and squared board tenure ($EIS \times BT^2$), the analyses show that a non-significant result (p = 0.101). This result shows that there is little evidence of the presence of a non-linear tenure pattern that may strengthen or weaken the relationship of environmental innovation with firm performance. Therefore, it could be possible that tenure length affects firm performance in a curvilinear manner, but it is highly unlikely that this particular pattern of tenure length would affect the relationship of environmental innovation with firm value. Moving on to board gender diversity in the quadratic model (BGD^2), the analysis shows that a non-linear relationship is negative and of no significance (p = 0.211). Therefore, this model did not provide substantial evidence that a non-linear relationship between gender diversity and performance exists, and the interaction term ($EIS \times BGD^2$) was also non-significant (p = 0.132), indicating that non-linear gender diversity is not a moderating variable.

Overall, although there are some signs that a non-linear effect may be associated with board tenure, neither board tenure nor gender diversity, whether assessed in a linear fashion or a quadratic one, constitutes a robust moderator between environmental innovation and firm performance. It is highly probable that the effectiveness of environmental innovation in enhancing firm value is primarily a function of other governance systems or specific attributes of firms.

DISCUSSION

The Impact of Environmental Innovation on Firm Performance in ASEAN-5 Countries

For many firms today, environmental innovation is a vital element in formulating corporate strategies for achieving sustainable growth and responding to intensifying global pressures to conduct business in a more responsible manner. For the ASEAN-5 countries, the integration of green innovation into their rapidly growing economies presents a range of unique challenges and opportunities. Environmental innovation entails new techniques, products, processes, or management systems that are developed to counteract environmentally harmful practices (Rennings, 2000). The evidence so far suggests that firms that adopt green innovations improve operational efficiency and corporate reputation and are likely to be in a better competitive position in the marketplace (Porter & Van Der Linde, 1995). For example, Xie et al. (2019) show that, environmentally innovative processes and products create new market opportunities for firms and may result in more efficacious production and, consequently, better financial performance. In addition, Li et al. (2017) explain that through the combination of legitimacy pressures and profit maximization, environmentally innovative practices are beneficial to firms and enhance their performance.

In ASEAN, policies like green tariffs and carbon taxes, along with changing green product demand, create a green innovation push. In previous regression analyses, we found that the Environmental Innovation Score (EIS) has a positive and significant relationship with Tobin's Q. Flexibility measures that used Return on Assets (ROA) firm performance also showed the same results. Our results are in line with Tripopsakul (2025). Their panel data indicates green innovations in ASEAN countries lead to improved ROA and firm value and that green innovations contribute to improved links between ESG and financial performance.

Our findings align with those of Horbach et al. (2012), who indicate that environmental innovations help firms achieve compliance with regulations and have a larger impact on efficiency and productivity. L. Liu (2024) notes that both substantive and strategic green innovations will enhance firm performance, although perhaps to different degrees. As the ASEAN-5 economies gradually shift to low-carbon development, firms more focused on environmental innovations will derive new economic opportunities and social acceptance. Research indicates that, although the degree of environmental innovation differs across the ASEAN countries, the beneficial influence of environmental innovation on firm performance is observed. For example, Singapore is able to lead in sustainable innovation through the Singapore Green Plan 2030, while the efforts of Indonesia and the Philippines focus on the establishment of stronger regulations and supportive frameworks (Secretariat ASEAN, 2021). This further demonstrates the importance of government aid in the environmental efforts of the ASEAN-5.

In conclusion, environmental innovations measure firm performance better in the ASEAN-5 than broad measures like the EIS, or even direct measures like the management of resources and wastes. Sustainability enhances the ability of firms to better cope with pressures from the global market and to outpace regional and global competitors. The findings provide good insights to support the triple bottom line because they underscore that corporate innovation, social responsibility, and environmental sustainability are essential for corporate success.

Board Tenure as a Moderator of the Relationship Between Environmental Innovation and Firm Performance

Board tenure has some correlation with corporate governance and how effectively board members and executives interact or carry out their roles. There has not been a clear correlation to establish how a director's tenure relates to corporate strategy, especially when it comes to considering corporate environmental innovations. From my interpretation of the available literature, it creates a paradox: within a firm, long-serving directors offer knowledge that promotes the firm's strategic needs, but at the expense of creating a trap for firm management leading to complacency (Livnat et al., 2021; Sun & Bhuiyan, 2020). Moreover, when we focus on the ASEAN-5 countries (Indonesia, Malaysia, Thailand, the Philippines, and Vietnam), the different board composition coupled with the differing levels of sophistication in their governance systems increases the complexity of dealing with this paradox. Our fixed effects regression analysis has shown that the combination of the Environmental Innovation Score (EIS) and board tenure (BT) has shown to not have a positive or negative significant effect on firm performance, as reflected by Tobin's Q or Return on Assets (ROA). This indicates that board tenure does not explain the financial implications of corporate environmental innovations.

We also investigated the possibility of a non-linear relationship by including a quadratic term (BT^2) and its interaction with EIS ($EIS \times BT^2$). The results are consistent with Huang (2013), who identifies the duality of board tenure. Novice directors lack the ability to understand the nuances of the long-term strategy. Meanwhile, directors with longer tenure often become disengaged and lack a critical approach. Livnat et al. (2021) argue that an entrenched board does not actively respond to new risks or changes in strategies. Thus, the lack of dynamism inhibits the ability of a board to transform innovative green strategies into excellent performance.

To assess the credibility of our findings, we undertook robustness checks. These involved substituting the broad EIS with specific environmental indicators, namely, waste management and resource consumption. Interestingly, with waste management operationalized as a measure and board tenure as a moderating variable, the interaction term was significant with a positive coefficient at the 10% level when ROA served as the dependent variable. Based on these findings, board tenure within this context has positively strengthened the relationship of better-financial-performance firms with effective waste management. However, in this context, due to the heterogeneous nature of environmental indicators, these findings are not generalizable as in the majority of other models, and with the majority of environmental indicators, the tenure interaction was either non-significant or displayed varying coefficients with different signs. This explains the varying effects of board tenure on a firm as stated by (Sun & Bhuiyan, 2020).

In reality, the effectiveness of board tenure in the ASEAN-5 countries is principally defined by their institutional and corporate cultures. In countries such as Indonesia and Vietnam, where family ownership is combined with weak evaluative mechanisms, boards are often more or less permanent (Claessens & Yurtoglu, 2013). In Malaysia, a limit on the tenure of independent directors is being implemented in order to introduce new viewpoints and offer a greater degree of accountability. Because of such variations across the region, board tenure cannot be seen as having a generalized effect. Instead, it should be viewed in the context of local governance systems and the state of regional institutional systems.

Our results show that in the case of environmental innovation and corporate performance, board tenure does not have a dependable or consistent effect. Even in the case of waste management, which shows some effect, board tenure is a weak and poor moderating variable. The validity of the more green orientation of innovation compared to the monetarization of innovation is being made by focusing on the quality of the board, not the length. The quality of the board may be assessed as a function of the quality of the board's members.

Board Gender Diversity as a Moderator of the Relationship Between Environmental Innovation and Firm Performance

The inclusion of women on corporate boards is considered to be a positive advancement towards a corporation's good governance, especially when evaluating corporate strategy and sustainability. The ongoing transition to sustainability and increasing focus on ESG (Environmental, Social, and Governance) concerns, indicate that boards that are gender-diverse tend to be more socially aware and provide a broader range of perspectives, in particular when they face the task of developing and implementing strategies that incorporate green innovations (Post & Byron, 2015).

Model 1 of our base model regression indicates that Board Gender Diversity (BGD) has a significant negative impact on firm performance. In this data, the representation of women on corporate boards correlates with a lower Tobin's Q. In Model 2, the interaction term (EIS × BGD) shows a positive strong and significant effect. This suggests that Board Gender Diversity has a positive impact on the financial returns of environmental innovations. Therefore, although a greater representation of women on boards does not positively impact the overall value of the firm, it does positively impact the financial returns of environmental innovations.

To analyze this dynamic further, we performed a quadratic test by including BGD^2 and the interaction term of environmental innovation (EIS × BGD^2). Both terms were found to be statistically insignificant. The results indicate that our data do not support the existence of a non-linear (curvilinear) effect, neither for the direct effect of gender diversity nor for the moderating effect. We further examined this issue by performing several robustness checks, in which we replaced the broad EIS measure with specific indicators of environmental issues, including waste and resource management. Within these analyses, the interaction of BGD and resource management was found to be significant ($p = 0.099$). This indicates that an increased proportion of female directors on the board is associated with an enhanced effect of resource management on the improvement of a firm's profitability.

These results illustrate that the consequences of board gender diversity are very contextual. Most importantly, our main model shows that board diversity more strongly associates green innovation with positive financial outcomes. However, we found no evidence of non-linearity. Furthermore, the moderating effect of gender diversity becomes evident when measuring environmental innovation through operational acts as opposed to broad measures. Consequently, contrary to several studies (Joecks et al., 2013; Richard et al., 2004), this study does not provide evidence supporting the existence of the so-called "critical mass" of women in boards.

CONCLUSION

This study examines the role of board gender diversity and board tenure in the environmental innovation-firm performance nexus in the ASEAN-5 region. Our baseline regression (Model 1) shows a positive and significant effect of environmental innovation (with the Environmental Innovation Score (EIS)) on firm performance (with Tobin's Q). In Model 2, the moderating variables were added, and the effect became statistically insignificant. This means that the governance structure of the firms mainly explains the nexus between green policies and financial performance. As a result, we substantiate Chassagnon and Haned (2015), Farza et al. (2021), Hizarci-Payne et al. (2021), Hojnik and Ruzzier (2016), Iqbal et al. (2022), Khalil et al. (2024), and Mac Lennan et al. (2023) that green innovations create firms' competitiveness and value.

Considered as moderators, board characteristics create a scenario in which things are a lot more complicated. Board tenure does not impact the performance of the firm (Fayyaz et al., 2025; Gavana et al., 2024). In terms of moderation, the impact is slightly negative and marginally significant, indicating that long director tenure diminishes the financial gains from environmental innovation. Our quadratic analysis indicates a marginally significant positive impact for the squared variable of board tenure (BT^2), indicating a possible non-linear effect. However, the interaction of EIS with BT^2 is found to be non-significant, indicating that the non-

linear tenure effect is not significant in determining the relationship of green innovation and performance. These findings support the claim that the long tenure of directors does not lead to the improvement of the board's oversight mechanisms, and may in fact reduce them (Vafeas, 2003), especially in the case of the unique corporate environment of the ASEAN-5.

In contrast, moderation of board gender diversity (BGD) is more substantial. BGD shows a significant negative direct effect on firm performance, but its interaction with environmental innovation (EIS × BGD) shows a positive effect. This implies that financially, diverse boards are better in the implementation of successful innovation. In effect, adding women to boards does not enhance firm value, but makes the firm's environmental innovation efforts more successful. Non-linear effects were tested using a quadratic specification of BGD^2 moderated by EIS; the results were non-significant.

Unlike some earlier studies Joecks et al. (2013) and Richard et al. (2004), our sample shows no evidence that gender diversity requires a specific "critical mass" threshold to be effective. Interestingly, our robustness checks revealed that when we measure green innovation through concrete operational actions—such as resource use—the interaction between BGD and resource use becomes marginally positive and significant. This tells us that gender diversity shines brightest at the operational level, specifically when driving resource efficiency to boost profitability.

Ultimately, this study expands our theoretical understanding of how environmental innovation, firm performance, and board traits intersect. The findings highlight that corporate boards play a complex, context-dependent role, with gender diversity acting as a much more relevant moderator than board tenure. Practically speaking, our results demonstrate that the success of green initiatives does not just depend on technology or strategy; it relies heavily on solid governance and the inclusion of diverse perspectives in the boardroom. For regulators in the ASEAN-5 region, the message is clear: corporate governance frameworks need an upgrade. Policymakers should intervene to improve board effectiveness—for instance, by monitoring director tenure and actively promoting gender diversity—to ensure environmental innovation translates into tangible firm performance. Of course, because these dynamics vary by context, regulators must carefully consider local institutional conditions before drafting new mandates.

While this research offers valuable insights, we must acknowledge a few limitations. First, we only analyzed firms with available ESG data, meaning our sample might not accurately represent the broader corporate landscape, particularly small and medium-sized enterprises. Second, by using aggregate indicators to measure environmental innovation, we might overlook the nuances of specific firm-level or industry-level practices. Third, our moderating analysis relied solely on linear and quadratic models without factoring in broader institutional or macroeconomic variables. Future researchers should aim to expand the dataset, use mixed-method approaches, and apply advanced analytical frameworks like moderated mediation models. We also recommend that upcoming studies incorporate country-level institutional factors and look beyond financial performance to include non-financial metrics like corporate reputation, regulatory compliance, and stakeholder perception. In conclusion, strategic and technological factors alone do not determine the success of environmental innovation; corporate governance structures—especially board composition—are just as critical. Aligning governance practices with sustainability goals is absolutely essential for driving long-term value creation across the ASEAN-5 region.

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