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# WHEN INVESTMENT UNDERMINES SUSTAINABILITY: THE MODERATING ROLE OF CAPEX IN THE ESG–ENVIRONMENTAL INNOVATION RELATIONSHIP



SINTA 2

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## ABSTRACT

Environmental innovation is increasingly important as firms face growing pressure to translate sustainability commitments into tangible environmental outcomes. This study examines the effects of Environmental, Social, and Governance (ESG) performance and the Environmental Pillar on environmental innovation and investigates whether Capital Expenditure (CAPEX) moderates the relationship between ESG performance and environmental innovation among publicly listed firms in Indonesia, Malaysia, and Singapore. Using secondary panel data comprising 250 firm-year observations from 2020 to 2024, this study employs random effects panel regression. The results indicate that ESG performance and the Environmental Pillar have positive and statistically significant effects on environmental innovation. However, CAPEX does not exhibit a statistically significant direct effect in the moderation models, and the interaction between ESG and CAPEX is not statistically significant. Significant cross-country differences in environmental innovation are also observed. These findings highlight the importance of ESG and environmental performance in promoting environmental innovation, while providing no evidence that CAPEX moderates this relationship.

**Keywords:** environmental innovation; ESG; environmental pillar; CAPEX; ASEAN.

## INTRODUCTION

The ASEAN region faces substantial challenges in implementing environmental sustainability and promoting environmental innovation across countries with different regulatory, economic, and institutional conditions. While countries such as Singapore have made considerable progress in ESG practices and environmental performance, Indonesia and Malaysia continue to face challenges in environmental regulation and its implementation (Aulia et al., 2023). These differences may result in varying degrees of ESG integration into corporate strategies, particularly in firms' efforts to develop environmental innovation. Consequently, understanding how firms translate ESG commitments into environmental innovation is particularly important in the ASEAN context.

An increase in ESG performance does not necessarily correspond to a proportional increase in green investment, as capital expenditure may be allocated across various types of corporate assets and investments with different implications for environmental innovation

(Nsiah et al., 2025). This condition suggests that Capital Expenditure (CAPEX) does not necessarily represent a direct commitment to sustainability because corporate investments may primarily support production capacity and economic expansion. Therefore, the allocation of CAPEX is important for understanding whether corporate resources are directed toward environmental objectives. The strategic direction of investment may consequently determine whether ESG commitments are effectively translated into environmental innovation.

Recent empirical studies also report inconsistent relationships between ESG performance and environmental innovation (Dicuonzo et al., 2022). Several studies identify a significant positive relationship between ESG and environmental innovation (Alodat et al., 2025; Pinheiro et al., 2024), whereas other studies indicate that the relationship may become insignificant or weaker when financial factors such as investment and capital structure are considered (Vierescu et al., 2025). This inconsistency suggests that the relationship between ESG and environmental innovation may depend on additional organizational and financial conditions. CAPEX is therefore considered an important contingency factor because corporate investment decisions determine how resources are committed to productive and sustainability-related activities.

This relationship can be explained primarily through Resource Allocation Theory, which emphasizes that organizational outcomes depend on how available resources are allocated among competing strategic priorities (Helfat & Maritan, 2024). From this perspective, strong ESG performance establishes a strategic orientation toward sustainability, but its implementation requires adequate allocation of corporate resources. CAPEX can support environmental innovation when it is directed toward green technologies, environmentally efficient production systems, and other assets that facilitate environmental improvements (Casciello et al., 2024). Conversely, when CAPEX is primarily allocated to conventional assets, the resources available for environmental innovation may be constrained. Thus, CAPEX can function as an important mechanism through which ESG commitments are translated into environmental innovation.

The role of CAPEX becomes particularly relevant when examining its moderating effect on the ESG–environmental innovation relationship. ESG performance may create organizational commitments and strategic priorities related to sustainability, but these commitments do not automatically generate environmental innovation without appropriate resource allocation. When CAPEX is aligned with environmental objectives, investment resources can facilitate the implementation of ESG strategies and potentially strengthen their contribution to environmental innovation. However, the extent to which CAPEX supports environmental objectives may depend on how investment resources are allocated across different corporate activities. Consequently, higher levels of CAPEX may weaken the extent to which ESG performance is translated into environmental innovation when capital investments are not sufficiently aligned with environmental objectives. This mechanism suggests that the effect of ESG performance on environmental innovation may vary according to firms' investment allocation decisions.

Previous studies have predominantly examined the direct role of ESG in promoting environmental innovation, with comparatively limited attention to the interaction between ESG performance and corporate investment decisions (Li et al., 2023). At the same time, the effectiveness of ESG strategies depends on the availability and allocation of resources necessary for their implementation (Aich et al., 2021). This limitation leaves an important gap in understanding how CAPEX influences the relationship between ESG and environmental innovation, particularly in emerging ASEAN markets. Examining this relationship may

therefore provide additional insight into why firms with similar ESG commitments can generate different environmental innovation outcomes.

ESG integration, as a means to corporate sustainable development, is now gaining popularity. However, empirical studies show that its effectiveness in driving environmentally-oriented innovation is still mixed (Cervino & Mendi, 2024). One rationale for ESG fostering environmental innovation is the regulatory demands and expectations of stakeholders (Nagriwum et al., 2025). However, the reality of ESG is more complex; it's not uncommon for the necessary investment to be misdirected or insufficiently aligned with strategic sustainability priorities, resulting in a discrepancy between a company's sustainability commitments and its innovation capabilities (David et al., 2024). This issue becomes more complex when CAPEX reflects firms' investment behavior. Theoretically, CAPEX should support innovation, including environmental innovation, by providing a sufficient resource base (O'Connell et al., 2025). However, in practice, CAPEX is seldom a channel through which sustainability-related spending is made, and therefore it has the potential to decouple or even reverse the link between ESG and environmental innovation (Erdoğan et al., 2025). This condition creates an ironic situation: an increase in corporate investment does not necessarily correspond to an increase in environmental innovation.

In the context of Indonesia, Malaysia, and Singapore (ASEAN-3), differences in economic characteristics, regulations, and levels of ESG implementation further reinforce the urgency to examine these relationships in more depth (Purnomo et al., 2025). This fluctuation begs the question of whether environmental innovation and ESG have a consistent relationship or if contextual factors, such as the company's investment choices, have an impact. Therefore, this study answers several research questions that were formed, including:

**RQ1: Does ESG have a positive effect on environmental innovation in companies in ASEAN-3?**

**RQ2: Does the environmental performance have a positive effect on environmental innovation in companies in ASEAN-3?**

**RQ3: Does CAPEX negatively affect environmental innovation in companies in ASEAN-3?**

**RQ4: Does CAPEX moderate the relationship between ESG and environmental innovation in companies in ASEAN-3?**

**RQ5: Are environmental innovation levels different in countries from the ASEAN-3 region?**

By examining whether CAPEX actually reduces the strength of the ESG- environmental innovation association, this study introduces novelty to the existing literature. This method helps grow the knowledge about ESG and environmental innovation, and it also helps explain why some companies, especially in the ASEAN-3 region, invest in ways that seem contradictory. The study also offers useful advice for businesses to be more thoughtful about where they spend their money and for government officials to create better rewards that make it easier and more appealing for people to invest in green projects.

ESG is seen as a way for companies to plan strategically by including sustainable practices in how they run their business (Alhoussari, 2025). From a stakeholder theory perspective, companies that adopt ESG comprehensively will strive to meet the demands of various stakeholders, including environmental protection, thereby encouraging greater environmental innovation (Wong et al., 2023). In addition, legitimacy theory explains that companies seek to gain social legitimacy through real sustainability practices, one of which is

the development of environmental innovation as a form of environmental responsibility (Olateju et al., 2021).

Empirically, various studies show that companies with high ESG performance tend to have better levels of environmental innovation due to regulatory pressures and market expectations to create sustainable value (Chouaibi & Chouaibi, 2021). Strong ESG performance can encourage firms to integrate sustainability considerations into organizational strategies and innovation activities, thereby increasing their capacity to develop environmental solutions. Accordingly, firms with higher ESG performance are expected to demonstrate greater environmental innovation. So, the hypothesis formed is as follows:

**H1: ESG performance has a positive effect on environmental innovation among companies in ASEAN-3.**

The environmental dimension of ESG is particularly relevant to environmental innovation because it directly addresses energy efficiency, emissions reduction, resource conservation, and waste management. Consistent with the Porter Hypothesis, environmental pressures can stimulate firms to develop innovations that improve resource efficiency and reduce long-term costs (Porter & Linde, 1995). From the Resource-Based View (RBV), environmental capabilities can also constitute valuable and difficult-to-imitate resources that enable firms to develop innovative solutions and achieve competitive advantage (Barney, 1991). Empirical evidence further indicates that the environmental dimension may exert a stronger influence on environmental innovation than other ESG dimensions because of its direct connection to firms' environmental practices and technological responses (Mneimneh et al., 2023). Therefore, stronger environmental performance is expected to enhance environmental innovation. So, the hypothesis formed is as follows:

**H2: Environmental performance has a positive effect on environmental innovation among companies in ASEAN-3.**

CAPEX represents firms' capital investment intensity in long-term productive assets and reflects the extent to which firms commit resources to capital investment activities (Szymanska & Keller, 2025). Although CAPEX can provide the resources required for technological development and innovation, its effect on environmental innovation depends on the direction and purpose of investment. From a resource allocation perspective, the contribution of capital investment to innovation depends on how firms deploy their investment resources and whether these investments support innovation-related activities (Bower, 2018). However, a higher level of capital investment does not necessarily imply greater investment in environmental innovation. When firms devote substantial capital resources to conventional productive assets or investments with limited environmental relevance, the contribution of CAPEX to environmental innovation may be limited (Casciello et al., 2024).

Agency theory provides an additional explanation for why greater capital investment intensity may not necessarily enhance environmental innovation. Managers may prioritize investments with relatively predictable or shorter-term returns over environmental innovations that involve greater uncertainty and longer payback periods (Vasconcelos & Ribeiro, 2026). Consequently, higher CAPEX intensity does not necessarily translate into greater environmental innovation, particularly when capital investment is directed toward projects with limited environmental relevance (O'Connell et al., 2025). Thus, higher CAPEX intensity may be associated with lower environmental innovation when capital investment is concentrated in activities that do not directly support environmental objectives. So, the hypothesis formed is as follows:

### **H3: CAPEX has a negative effect on environmental innovation among companies in ASEAN-3.**

The positive effect of ESG performance on environmental innovation depends not only on firms' sustainability commitments but also on their ability to allocate resources toward implementing those commitments. Resource allocation theory suggests that strategic priorities generate organizational outcomes only when adequate resources are directed toward their implementation (Bower, 2018; Wang et al., 2023). In this context, CAPEX intensity represents the extent to which firms commit resources to capital investment and may influence their capacity to translate ESG commitments into environmental innovation.

Higher CAPEX intensity may strengthen the ESG–environmental innovation relationship when firms' capital investments provide the physical and technological resources necessary to implement sustainability-oriented strategies. For example, capital investments in clean technologies, energy-efficient equipment, pollution-control systems, renewable energy infrastructure, and environmentally oriented production processes may provide the physical and technological resources required to translate ESG commitments into environmental innovation. Under these conditions, higher CAPEX complements ESG performance by increasing firms' capacity to implement sustainability-oriented strategies (Casciello et al., 2024).

Conversely, higher CAPEX intensity may weaken the ESG–environmental innovation relationship when capital investments are not sufficiently aligned with environmental objectives. From an agency perspective, managers may prioritize investments that generate more immediate or predictable financial returns, while environmental innovations may receive less capital because of their higher uncertainty and longer payback periods (Vasconcelos & Ribeiro, 2026). Under such circumstances, strong ESG performance may not translate into corresponding environmental innovation because the increased capital investment does not necessarily provide resources that are directly relevant to sustainability-oriented innovation.

Accordingly, CAPEX does not simply determine the level of environmental innovation; rather, it conditions the extent to which ESG performance can be converted into environmental innovation. When higher CAPEX intensity provides resources that support sustainability-oriented activities, it is expected to strengthen the ESG–environmental innovation relationship. Conversely, when capital investment is concentrated in activities with limited environmental relevance, higher CAPEX intensity may weaken this relationship. So the hypothesis formed is as follows:

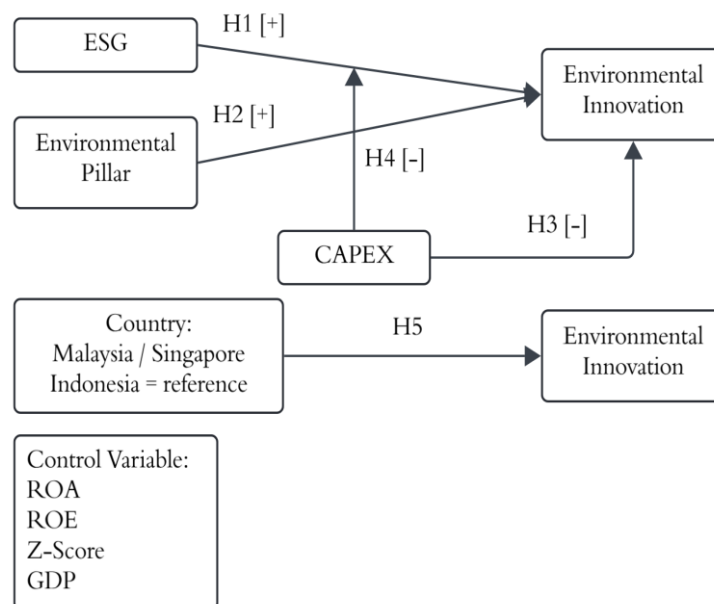
### **H4: CAPEX moderates the relationship between ESG and environmental innovation in companies in ASEAN-3.**

Environmental innovation may also vary across ASEAN-3 countries because firms operate within different institutional and economic environments. Indonesia, Malaysia, and Singapore differ in environmental regulations, technological capabilities, market conditions, and institutional pressures, which may shape firms' incentives and capacity to undertake environmental innovation (Pratama et al., 2025). Institutional theory suggests that differences in regulatory and institutional environments influence organizational responses to sustainability pressures and the adoption of sustainability-oriented practices (Shubham et al., 2018).

Empirical evidence indicates that firms operating under more stringent environmental regulations tend to exhibit higher levels of environmental innovation because regulatory pressure encourages firms to develop technological and organizational responses to environmental challenges (Borsatto & Amui, 2019). Given the institutional differences among Indonesia, Malaysia, and Singapore, environmental innovation may therefore differ across the three countries. So, the hypothesis formed is as follows:

**H5: There are differences in environmental innovations between countries in the ASEAN-3 region.**

Figure 1 summarizes the conceptual framework and hypothesized relationships developed in this study. The framework illustrates the expected effects of ESG performance and the Environmental (E) pillar on environmental innovation (H1 and H2), the direct effect of CAPEX on environmental innovation (H3), and the moderating role of CAPEX in the ESG–environmental innovation relationship (H4). It also incorporates country differences across Indonesia, Malaysia, and Singapore as proposed in H5, while controlling for relevant firm- and country-level characteristics. Overall, the framework provides an integrated representation of the relationships empirically examined in the ASEAN-3 context.



**Figure 1. Conceptual Framework and Hypothesized Relationships**

Source: Authors, 2026

## METHODS

This study employs a quantitative research approach to examine the relationships among ESG, Environmental Pillar, CAPEX, and Environmental Innovation in publicly listed companies across the ASEAN-3 countries, namely Indonesia, Malaysia, and Singapore. Quantitative research is appropriate because it enables researchers to test hypotheses objectively through statistical analysis and to evaluate causal relationships among variables using numerical data (Creswell, 2018). Furthermore, this approach provides empirical evidence that can be generalized to the selected sample and supports theory validation through econometric analysis.

This study only uses secondary data from globally renowned databases that are accessible to the public. Data on Environmental Innovation, ESG Score, and Environmental Pillar Score are collected from the Refinitiv (LSEG Workspace) database, while financial data used to calculate CAPEX, Return on Assets (ROA), Return on Equity (ROE), and Altman Z-Score (ZS) are obtained from companies' annual reports and financial statements. In addition, country-level macroeconomic data, particularly Gross Domestic Product (GDP) Growth, are collected from official international statistical sources. The use of secondary data offers several advantages, including broad coverage across firms and countries, consistent measurement, and greater reliability in empirical research, particularly in cross-country panel studies (Hair et al., 2022).

This study uses panel data regression analysis to test the hypotheses by integrating time-series observations over several years with cross-sectional observations of businesses. This method is suitable because it controls for unobservable firm-specific heterogeneity, improves estimation efficiency, and captures both temporal and cross-country variations in environmental innovation across ASEAN-3 companies (Baltagi, 2021).

This study covers companies from all sectors listed on the Indonesia Stock Exchange (IDX), Singapore Exchange (SGX), and Bursa Malaysia (MYX) during the 2020–2024 observation period. A purposive sampling technique was applied based on the availability and consistency of environmental innovation and ESG data required for the analysis.

The relatively large reduction in the sample size reflects the strict data-availability criteria applied in this study. Environmental innovation data are not uniformly available for all listed firms, particularly across emerging and developing capital markets. Although many firms disclose general sustainability or ESG information, considerably fewer firms have sufficiently consistent and comparable environmental innovation data over the entire 2020–2024 observation period. Therefore, firms without the required environmental innovation and ESG data were excluded from the final sample. This screening procedure was necessary to ensure consistency in the measurement of the dependent and independent variables and to avoid constructing an unbalanced dataset from incomplete observations. The sample selection process is presented in Table 1.

**Table 1. Sample Selection**

| Description                                                                      | Companies in Indonesia | Companies in Singapore | Companies in Malaysia |
|----------------------------------------------------------------------------------|------------------------|------------------------|-----------------------|
| Companies listed on the respective stock exchanges during the study period       | 920                    | 572                    | 1082                  |
| Companies without sufficient environmental innovation and ESG data for 2020–2024 | (908)                  | (556)                  | (1060)                |
| Final number of companies with the required data                                 | 12                     | 16                     | 22                    |
| Number of observations (5 years)                                                 | 60                     | 80                     | 110                   |

Source: Data processed, 2026

The final sample consists of 50 companies, comprising 12 companies from Indonesia, 16 from Singapore, and 22 from Malaysia. With five annual observations for each company during 2020–2024, the resulting balanced panel consists of 250 firm-year observations. The relatively small final sample should therefore be understood as a consequence of the availability of comparable environmental innovation and ESG data rather than as a random exclusion of firms. The analysis was conducted using STATA 17. The statistical procedures

included diagnostic tests for the panel-data model and regression analysis to examine the direct and moderating relationships proposed in the hypotheses.

The dependent variable in this study is environmental innovation, which is measured using firm-level data from the Refinitiv database provided through Thomson Reuters/LSEG. Environmental innovation refers to a firm's ability to reduce costs and environmental impacts for its customers while creating new market opportunities through green technologies, processes, or products designed with sustainability considerations. This measure has been widely adopted in previous empirical studies examining corporate environmental performance and innovation (Drempetic et al., 2020; Hussain et al., 2024). The use of the Refinitiv measure enables environmental innovation to be assessed consistently across firms and countries within the ASEAN-3 sample.

The description and measurement of the study variables are presented in Table 2. The main independent variables are the ESG Score and Environmental Pillar Score, both obtained from the Refinitiv/LSEG Workspace database. The ESG Score captures the extent to which firms incorporate sustainability principles across environmental, social, and governance dimensions, whereas the Environmental Pillar Score specifically evaluates firms' environmental performance, including resource utilization, waste management, energy efficiency, emissions control, and environmental innovation. Both measures range from 0 to 100, with higher scores indicating stronger sustainability performance. From the Resource-Based View and Stakeholder Theory perspectives, firms with stronger ESG and environmental performance are expected to possess greater organizational capabilities and stakeholder responsiveness that can facilitate environmental innovation (Barney, 1991; Refinitiv, 2022; Sulkowski et al., 2018).

CAPEX is employed as the moderating variable to examine whether the intensity of capital investment influences the relationship between ESG performance and environmental innovation. CAPEX is operationalized as capital expenditures divided by the book value of total assets, following Ki and Adhikari (2023). The ratio measures the intensity of capital investment relative to the firm's asset base and allows CAPEX to be compared across firms with different sizes. Higher values indicate greater capital investment intensity. Capital expenditure data and total asset values are obtained from the Thomson Reuters/LSEG database.

$$CAPEX\ Ratio_{it} = \frac{Capital\ Expenditures_{it}}{Total\ Assets_{it}} \frac{Capital\ Expenditure}{Operating\ Cash\ Flow} \quad (1)$$

This measure captures the extent to which firms commit their operating cash resources to long-term capital investments. In the context of this study, CAPEX is used to assess whether the allocation of investment resources strengthens or weakens the ability of ESG performance to translate into environmental innovation.

To reduce the risk of omitted variable bias and obtain a more precise assessment of the relationships among ESG performance, Environmental Pillar performance, CAPEX, and environmental innovation, the study incorporates four control variables: GDP growth, Altman Z-Score, Return on Equity (ROE), and Return on Assets (ROA). GDP growth captures differences in the broader economic environment across countries and years, while the Altman Z-Score controls for firms' financial stability and potential financial distress. ROE measures the firm's ability to generate returns from shareholders' equity, whereas ROA captures the efficiency with which firms utilize their assets to generate profits. Including these variables

helps account for firm-level financial conditions and macroeconomic factors that may influence environmental innovation independently of ESG performance and CAPEX.

**Table 2. Variable Definition**

| Variable type      | Variable name             | Variable symbol | Definition                                                                                                                                       |
|--------------------|---------------------------|-----------------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| Dependent          | Environmental innovation  | EI              | Data are obtained from the Refinitiv database                                                                                                    |
| Independent        | ESG Score                 | ESG             | ESG Score data from the Refinitiv database                                                                                                       |
|                    | Environmental Pillar      | E               | Environmental pillar data from the Refinitiv database                                                                                            |
| Moderating Control | Capital Expenditure       | CAPEX           | Capital expenditures divided by total assets                                                                                                     |
|                    | Return on Asset           | ROA             | Net profit divided by total assets                                                                                                               |
|                    | Return on Equity          | ROE             | Net profit divided by total equity                                                                                                               |
|                    | Altman z-score            | ZS              | The analytical model used in the study is the Altman revised Z-score model (1983)                                                                |
|                    | GDP Growth                | GDP             | Country's GDP report                                                                                                                             |
|                    | Country Dummy (Malaysia)  | MLY             | Dummy variable indicating firms operating in Malaysia (1 = Indonesia; 2 = Malaysia; 3 = Singapore). Indonesia serves as the reference category.  |
|                    | Country Dummy (Singapore) | SGP             | Dummy variable indicating firms operating in Singapore (1 = Indonesia; 2 = Malaysia; 3 = Singapore). Indonesia serves as the reference category. |

Source: Data processed, 2026

ROA and ROE are chosen because they reflect the company's ability to generate profits from shareholders' assets and capital. Companies with high profitability generally have greater financial capacity to support investment in research, the development of green technologies, and the implementation of environmental innovations (Xiong & Dai, 2023). Furthermore, the Altman Z-Score is used as an indicator of a company's financial health. When it comes to devoting resources to sustainable innovation initiatives, firms in stronger financial standing typically have more leeway than those under financial strain (Wedari et al., 2023). Meanwhile, GDP is used as a macroeconomic control variable to capture differences in economic development levels among Indonesia, Malaysia, and Singapore. These differences in economic conditions can affect companies' access to technology, funding, and policies that support environmental innovation. By controlling for these four variables, the research model is expected to provide a more robust estimate of the influence of ESG and the Environmental Pillar on environmental innovation.

This study used panel data regression analysis to examine the influence of ESG and the Environmental Pillar on Environmental Innovation, and to test the moderating role of CAPEX among companies listed in Indonesia, Malaysia, and Singapore during the observation period. The analysis was carried out using two main models to mitigate potential multicollinearity, given that the Environmental Pillar is one of the dimensions comprising the ESG Score. In addition, this study included Return on Assets (ROA), Return on Equity (ROE), Altman Z-Score, and Gross Domestic Product (GDP) as control variables to control the influence of company characteristics and macroeconomic conditions on environmental innovation. Differences in characteristics across countries are controlled for using dummy variables, with Indonesia as the reference category (baseline), so that the coefficients for Malaysia and Singapore are interpreted as differences relative to Indonesia.

The empirical analysis is conducted through five complementary regression models designed to examine the relationship between ESG performance, environmental performance, capital expenditure, and environmental innovation among publicly listed companies in the ASEAN-3 region. The models are estimated using a consistent set of control variables, including return on assets (ROA), return on equity (ROE), the Altman Z-Score, GDP growth, and country dummy variables. The inclusion of these controls helps account for differences in firm-level financial characteristics and macroeconomic conditions that may independently influence firms' capacity to undertake environmental innovation.

The first model was used to test the influence of the ESG Score on Environmental Innovation in companies in the ASEAN-3 region. This model also includes control variables, including ROA, ROE, the Altman Z-Score, GDP, and a country dummy, to control for differences in company characteristics and economic conditions across countries. The Model 1 equation is formulated as follows.

$$EI_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 ROA_{it} + \beta_3 ROE_{it} + \beta_4 ZS_{it} + \beta_5 GDP_{it} + \beta_6 MLY_{it} + \beta_7 SGP_{it} + \varepsilon_{it} \dots \dots \dots (2)$$

The second model aims to test the influence of the Environmental Pillar Score on Environmental Innovation. The use of this model is intended to determine whether the environmental dimension of ESG has a more specific influence on environmental innovation than the overall ESG score. The model also accounts for the influence of control variables and differences in characteristics across countries. The Model 2 equation is as follows.

$$EI_{it} = \beta_0 + \beta_1 E_{it} + \beta_2 ROA_{it} + \beta_3 ROE_{it} + \beta_4 ZS_{it} + \beta_5 GDP_{it} + \beta_6 MLY_{it} + \beta_7 SGP_{it} + \varepsilon_{it} \dots \dots \dots (3)$$

The third model tests the direct influence of CAPEX on Environmental Innovation. This model aims to determine whether an increase in a company's fixed asset investment directly affects its ability to generate environmental innovation. The control variables and the country dummy are still included to obtain a more robust estimate. The Model 3 equation is formulated as follows.

$$EI_{it} = \beta_0 + \beta_1 CAPEX_{it} + \beta_2 ROA_{it} + \beta_3 ROE_{it} + \beta_4 ZS_{it} + \beta_5 GDP_{it} + \beta_6 MLY_{it} + \beta_7 SGP_{it} + \varepsilon_{it} \dots \dots \dots (4)$$

The fourth model was used to test whether CAPEX moderates the relationship between ESG and Environmental Innovation. The test was performed by adding interaction variables between ESG and CAPEX ( $ESG \times CAPEX$ ) into the regression model. The coefficient on the interaction variable indicates whether CAPEX strengthens or weakens the influence of ESG on environmental innovation. The Model 4 equation is as follows.

$$EI_{it} = \beta_0 + \beta_1 ESG_{it} + \beta_2 CAPEX_{it} + \beta_3 (ESG_{it} \times CAPEX_{it}) + \beta_4 ROA_{it} + \beta_5 ROE_{it} + \beta_6 ZS_{it} + \beta_7 GDP_{it} + \beta_8 MLY_{it} + \beta_9 SGP_{it} + \varepsilon_{it} \dots \dots \dots (5)$$

The fifth model was used to test whether there were differences in Environmental Innovation between companies in Indonesia, Malaysia, and Singapore. The test was conducted through dummy countries, with Indonesia designated as the baseline category. Therefore, the coefficients of the dummy variables for Malaysia and Singapore indicate differences in the level of environmental innovation relative to Indonesia after accounting for the influence of

other variables. The H5 hypothesis is supported if at least one of the state dummy coefficients is statistically significant.

## RESULT AND DISCUSSION

Based on 250 firm-year observations from publicly traded businesses in Indonesia, Malaysia, and Singapore, Table 3 displays the descriptive statistics of the variables employed in this study. With an average EI score of 50.341 and a standard deviation of 25.253, the ASEAN-3 countries' enterprises' environmental innovation performance varies significantly. The Environmental Pillar Score (E) averages slightly higher at 62.635 than the mean ESG Score of 62.546, indicating that the sampled firms generally demonstrate a reasonable level of sustainability performance, particularly in environmental activities.

**Table 3. Descriptive Statistics**

| Variables | Obs | Mean   | Std. Dev. | Min    | Max    | p1     | p99    |
|-----------|-----|--------|-----------|--------|--------|--------|--------|
| EI        | 250 | 50.341 | 25.253    | 8.049  | 98.276 | 8.148  | 96.326 |
| ESG       | 250 | 62.546 | 14.253    | 9.803  | 91.142 | 18.083 | 90.2   |
| E         | 250 | 62.635 | 16.625    | 8.225  | 94.724 | 10.556 | 92.669 |
| CAPEX     | 250 | .041   | .035      | 0      | .171   | 0      | .146   |
| ROA       | 250 | .06    | .076      | -.205  | .348   | -.129  | .323   |
| ROE       | 250 | .163   | .293      | -.467  | 1.767  | -.343  | 1.329  |
| ZS        | 250 | 2.73   | 2.453     | -.45   | 11.772 | .136   | 10.988 |
| GDP       | 250 | 3.225  | 4.247     | -5.457 | 9.757  | -5.457 | 9.757  |

Source: Data processed, 2026

CAPEX has a mean of 0.041 and a standard deviation of 0.035, with values ranging from 0.000 to 0.171. The relatively moderate dispersion indicates differences in firms' capital investment intensity relative to their asset base. Regarding the control variables, the mean values of ROA and ROE are 0.060 and 0.163, respectively, indicating that the sampled firms generally maintain positive profitability. Furthermore, the average Altman Z-Score (ZS) of 2.730 suggests that most firms are financially stable and have a relatively low risk of financial distress. The average GDP Growth of 3.225% reflects the varying macroeconomic environments across Indonesia, Malaysia, and Singapore during the observation period. The dataset's suitability for further panel regression analysis is supported by the descriptive statistics, which generally show adequate variation across all variables.

The dependent, independent, moderating, and control factors' Pearson correlations are displayed in Table 4. The results show that the connection between the variables is not strong enough to be a problem, as their correlation values are below the standard limit of 0.80. This means that multicollinearity probably won't be a major issue when we do the regression analysis next (Hair et al., 2019).

The dependent variable, EI, exhibits a positive and statistically significant correlation with both the ESG Score ( $r = 0.330$ ,  $p < 0.01$ ) and the Environmental Pillar Score ( $r = 0.542$ ,  $p < 0.01$ ). These findings provide preliminary evidence that firms with stronger ESG performance and environmental management practices tend to achieve higher levels of environmental innovation, which is consistent with the theoretical perspective that sustainability-oriented governance encourages firms to develop environmentally friendly products, processes, and technologies (Chen & Xie, 2022; Porter & Linde, 1995).

In contrast, CAPEX exhibits a weak negative but statistically insignificant correlation with environmental innovation ( $r = -0.054$ ,  $p = 0.391$ ). This finding suggests that capital investment intensity relative to total assets is not significantly associated with environmental innovation at the bivariate level. The absence of a significant bivariate relationship does not, however, preclude a potential effect of CAPEX after controlling for firm characteristics and examining its interaction with ESG performance in the panel regression models.

**Table 4. Correlation Matrix**

| Variables | (1)               | (2)              | (3)               | (4)              | (5)              | (6)              | (7)               | (8)   |
|-----------|-------------------|------------------|-------------------|------------------|------------------|------------------|-------------------|-------|
| (1) EI    | 1.000             |                  |                   |                  |                  |                  |                   |       |
| (2) ESG   | 0.330<br>(0.000)  | 1.000            |                   |                  |                  |                  |                   |       |
| (3) E     | 0.542<br>(0.000)  | 0.733<br>(0.000) | 1.000             |                  |                  |                  |                   |       |
| (4) CAPEX | -0.054<br>(0.391) | 0.090<br>(0.156) | -0.057<br>(0.369) | 1.000            |                  |                  |                   |       |
| (5) ROA   | 0.061<br>(0.333)  | 0.068<br>(0.287) | 0.108<br>(0.089)  | 0.267<br>(0.000) | 1.000            |                  |                   |       |
| (6) ROE   | 0.215<br>(0.001)  | 0.169<br>(0.007) | 0.204<br>(0.001)  | 0.291<br>(0.000) | 0.857<br>(0.000) | 1.000            |                   |       |
| (7) ZS    | -0.044<br>(0.491) | 0.003<br>(0.958) | 0.070<br>(0.271)  | 0.165<br>(0.009) | 0.756<br>(0.000) | 0.672<br>(0.000) | 1.000             |       |
| (8) GDP   | 0.061<br>(0.338)  | 0.111<br>(0.081) | 0.130<br>(0.039)  | 0.012<br>(0.849) | 0.016<br>(0.800) | 0.024<br>(0.707) | -0.049<br>(0.436) | 1.000 |

Source: Data processed, 2026

Among the control variables, ROE is positively associated with environmental innovation ( $r = 0.215$ ,  $p < 0.01$ ), whereas ROA, Altman Z-Score (ZS), and GDP Growth are not statistically significant. Furthermore, the correlation between ESG and the Environmental Pillar is relatively strong ( $r = 0.733$ ,  $p < 0.01$ ), reflecting that environmental performance represents a fundamental component of overall ESG performance. Nevertheless, the correlation coefficient remains below the recommended threshold of 0.80, indicating that the variables can be estimated in separate regression models without introducing serious multicollinearity problems (Hair et al., 2019). Overall, the correlation analysis provides preliminary support for the proposed research model and confirms the dataset's suitability for subsequent panel regression analysis.

Before estimating the panel regression models, multicollinearity among the explanatory variables was assessed using the Variance Inflation Factor (VIF), with the results reported in Table 5. All variables exhibit VIF values below the conventional threshold of 10, while the corresponding tolerance values ( $1/VIF$ ) are above 0.10. These findings indicate that multicollinearity does not pose a significant concern for the subsequent regression analysis (Hair et al., 2019).

Specifically, the highest VIF value is observed for Return on Assets (ROA) at 5.479, followed by Return on Equity (ROE) at 4.439. Although these values are relatively higher than those of the other explanatory variables, they remain below the conventional threshold of 10, suggesting that multicollinearity is within an acceptable range. The independent variables ESG and Environmental Pillar (E) have VIF values of 2.599 and 2.420, respectively,

indicating moderate associations with the other explanatory variables but no serious multicollinearity. The moderating variable CAPEX and the control variable GDP have VIF values of 1.191 and 1.028, respectively, indicating relatively low levels of collinearity. Similarly, the country dummy variables for Malaysia (MLY) and Singapore (SGP) have VIF values of 1.819 and 2.045, respectively, suggesting that their inclusion does not create substantial multicollinearity. The mean VIF of 2.605 further indicates that the overall level of multicollinearity in the explanatory variables is relatively low. Therefore, the explanatory variables can be included simultaneously in the panel regression models without evidence of problematic multicollinearity.

As part of the diagnostic tests for the panel regression models, the study examined the data for the presence of first-order serial correlation. The Wooldridge test for autocorrelation in panel data was employed to determine whether the regression model exhibits first-order serial correlation, with the results reported in Table 6. The null hypothesis of the Wooldridge test states that there is no first-order autocorrelation in the panel data (Drukker, 2003). The test produces an F-statistic of 7.993 with a p-value of 0.0068. Since the probability value is below the conventional significance level of 1% ( $p < 0.01$ ), the null hypothesis of no first-order autocorrelation is rejected. The findings therefore indicate the presence of statistically significant first-order serial correlation in the panel dataset.

The presence of serial correlation indicates that the residuals may be correlated over time within firms. Therefore, conventional standard errors may not provide reliable statistical inference if the serial correlation is not appropriately addressed. To account for this issue, the subsequent random-effects regression models employ firm-clustered robust standard errors, which provide inference that is robust to within-firm serial correlation and heteroskedasticity. Accordingly, the presence of serial correlation does not invalidate the panel regression analysis but requires an appropriate adjustment to the estimation of standard errors.

**Table 5. Multicollinearity Analysis**

|          | VIF   | 1/VIF |
|----------|-------|-------|
| ESG      | 2.599 | .385  |
| E        | 2.42  | .413  |
| CAPEX    | 1.191 | .839  |
| ROA      | 5.479 | .183  |
| ROE      | 4.439 | .225  |
| ZS       | 2.422 | .413  |
| GDP      | 1.028 | .973  |
| 2.(MLY)  | 1.819 | .55   |
| 3.(SGP)  | 2.045 | .489  |
| Mean VIF | 2.605 | .     |

Source: Data processed, 2026

**Table 6. Autocorrelation Analysis**

| Test                            | Null Hypothesis                | Test Statistic | p-value | Decision  |
|---------------------------------|--------------------------------|----------------|---------|-----------|
| Wooldridge Autocorrelation Test | No first-order autocorrelation | F = 7.993      | 0.0068  | Reject H0 |

Source: Data processed, 2026

Following the diagnostic tests, panel model specification tests were conducted to identify the most appropriate estimation approach for the empirical analysis. The Chow, Breusch–Pagan Lagrange Multiplier (LM), and Hausman tests were employed to determine whether pooled OLS, Fixed Effects Model (FEM), or Random Effects Model (REM) should be selected (Baltagi, 2021). The results are presented in Table 7.

We reject the notion that the pooled ordinary least squares model is superior to the fixed-effects model since the Chow test yielded an F-statistic of 12.91 and a p-value of 0.000. The Fixed Effects Model is preferable to the pooled regression model since this result indicates that company differences are important.

The null hypothesis that the combined model is appropriate was then rejected after the Breusch–Pagan LM evaluation yielded a chi-square value of 131.48 and a p-value of 0.000. This result suggests that because the Random Effects Model (REM) takes into account unobservable individual influences, it is more suitable than the pooled OLS model.

The Hausman specification analysis ultimately produced a p-value of 0.4310 and a chi-square statistic of 8.03. We cannot rule out the null hypothesis because this probability value is higher than the 5% significance level, indicating that the Random Effects Model is more efficient and consistent than the Fixed Effects Model. The Random Effects Model (REM) was determined to be the best method for examining the suggested hypotheses based on the combined results of these three specification evaluations. As a result, the Random Effects Model was used for estimation in all subsequent regression analyses carried out in this study.

The Pesaran Cross-Sectional Dependence (CD) test was conducted to assess whether the residuals of the panel regression model are correlated across cross-sectional units, with the results reported in Table 8. The null hypothesis of the Pesaran CD test states that the cross-sectional units are independent, indicating the absence of statistically significant dependence across firms (Y. Xie & Pesaran, 2022).

**Table 7. Panel Model Selection**

| Test                       | Null Hypothesis                                | Test Statistic    | p-value | Decision             | Select Model   |
|----------------------------|------------------------------------------------|-------------------|---------|----------------------|----------------|
| Chow Test                  | Pooled OLS is preferred over Fixed Effects     | $F = 12.91$       | 0.000   | Reject $H_0$         | Fixed Effects  |
| Breusch–Pagan LM Test      | Pooled OLS is preferred over Random Effects    | $\chi^2 = 131.48$ | 0.000   | Reject $H_0$         | Random Effects |
| Hausman Specification Test | Random Effects is preferred over Fixed Effects | $\chi^2 = 8.03$   | 0.4310  | Fail to reject $H_0$ | Random Effects |

Source: Data processed, 2026

**Table 8. Cross-sectional Dependence**

| Test            | Null Hypothesis              | Test Statistic | p-value |
|-----------------|------------------------------|----------------|---------|
| Pesaran CD Test | Cross-sectional independence | -1.135         | 0.2563  |

Source: Data processed, 2026

The test produces a statistic of -1.135 with a p-value of 0.2563. Since the p-value is greater than the 5% significance level, the null hypothesis of cross-sectional independence cannot be rejected. This finding indicates that there is no statistically significant evidence of cross-sectional dependence among the firms in the panel dataset. The average absolute value

of the off-diagonal elements is 0.482, indicating the magnitude of the average pairwise correlation across the cross-sectional units.

Following the panel model specification and diagnostic tests, the study proceeded with the estimation of the proposed regression models to examine the hypothesized relationships among ESG, environmental performance, capital expenditure, and environmental innovation. The regression results presented in Table 9 show that ESG has a positive and statistically significant relationship with environmental innovation in both estimated models. ESG registers a coefficient of 0.662 with a t-value of 5.99 ( $p < 0.01$ ) in Model (1). The coefficient remains positive and statistically significant ( $t = 4.62$ ;  $p < 0.01$ ) but marginally drops to 0.504 after the control variables are included in Model (2). After adjusting for firm-level financial factors, macroeconomic conditions, and cross-country variations, the estimated association remains statistically significant across both parameters. This finding is also consistent with evidence from the ASEAN context, where higher ESG performance has been associated with stronger corporate resilience and market performance, suggesting that ESG can provide firms with strategic capabilities to respond to changing environmental and economic conditions (Ariyudha & Rokhim, 2025).

Regarding the control variables, ROA shows a negative and statistically significant coefficient ( $\beta = -121.845$ ;  $t = -2.81$ ;  $p < 0.01$ ), whereas ROE shows a positive and statistically significant coefficient ( $\beta = 52.559$ ;  $t = 5.26$ ;  $p < 0.01$ ) with environmental innovation. Similarly, Altman Z-Score (ZS) is negatively associated with environmental innovation ( $\beta = -2.210$ ;  $t = -2.48$ ;  $p < 0.05$ ). In contrast, GDP Growth does not exhibit a statistically significant effect on environmental innovation ( $\beta = 0.021$ ;  $t = 0.06$ ;  $p > 0.05$ ), indicating that variations in national economic growth do not substantially explain differences in firms' environmental innovation within the observed sample.

**Table 9. Regression Test of ESG on Environmental Innovation**

| EI                | (1)                   | (2)                    |
|-------------------|-----------------------|------------------------|
| ESG               | .662***<br>(5.99)     | .504***<br>(4.62)      |
| ROA               |                       | -121.845***<br>(-2.81) |
| ROE               |                       | 52.559***<br>(5.26)    |
| ZS                |                       | -2.21**<br>(-2.48)     |
| GDP               |                       | .021<br>(0.06)         |
| Country: base IDN |                       |                        |
| MLY               | -11.696***<br>(-3.06) | -15.171***<br>(-4.01)  |
| SGP               | -4.383<br>(-1.08)     | -10.282**<br>(-2.41)   |
| Constant          | 15.489**<br>(2.07)    | 33.473***<br>(4.13)    |
| R-squared         | 0.144                 | 0.242                  |
| F-test            | 13.756                | 11.064                 |

\*\*\*  $p < .01$ , \*\*  $p < .05$ , \*  $p < .1$

Notes: In parentheses is the "t" value

Source: Data processed, 2026

The country dummy variables reveal observable differences across the ASEAN-3 countries. Relative to Indonesia as the reference category, firms operating in Malaysia display significantly lower environmental innovation in both Model (1) ( $\beta = -11.696$ ;  $t = -3.06$ ;  $p < 0.01$ ) and Model (2) ( $\beta = -15.171$ ;  $t = -4.01$ ;  $p < 0.01$ ). Meanwhile, the coefficient for Singapore is statistically insignificant in Model (1), but becomes negative and significant in Model (2) ( $\beta = -10.282$ ;  $t = -2.41$ ;  $p < 0.05$ ) after firm-specific characteristics are controlled for. These results indicate that cross-country differences become more apparent when financial and macroeconomic factors are incorporated into the regression model.

Additionally, the control variables increase the explanatory power of the model. The extended model explains a greater percentage of the variation in environmental innovation, as evidenced by the R-squared increasing from 0.144 in Model (1) to 0.242 in Model (2). Furthermore, both regression models are jointly significant, as indicated by F-statistics of 13.756 and 11.064 ( $p < 0.01$ ), respectively, confirming that the explanatory variables collectively provide a statistically meaningful explanation of environmental innovation (Khanchel et al., 2023).

The Environmental Pillar (E) is positively and statistically strongly correlated with environmental innovation in both model parameters, as shown by the regression findings in Table 10. The Environmental Pillar in Model (1) has a t-value of 10.23 ( $p < 0.01$ ) and a coefficient of 0.829. The coefficient in Model (2) drops to 0.739 after the control factors are added, but it is still highly significant ( $t = 9.24$ ;  $p < 0.01$ ). The consistently positive coefficients and high statistical significance indicate that the relationship between the Environmental Pillar and environmental innovation remains stable after controlling for firm-level financial performance, macroeconomic conditions, and country-specific effects (Papke & Wooldridge, 2023).

**Table 10. Regression Test of the Environmental Pillar on Environmental Innovation**

| EI                | (1)                 | (2)                   |
|-------------------|---------------------|-----------------------|
| E                 | .829***<br>(10.23)  | .739***<br>(9.24)     |
| ROA               |                     | -100.019**<br>(-2.57) |
| ROE               |                     | 44.296***<br>(4.95)   |
| ZS                |                     | -2.406***<br>(-3.02)  |
| GDP               |                     | -.16<br>(-0.53)       |
| Country: base IDN |                     |                       |
| MLY               | -8.313**<br>(-2.46) | -12.402***<br>(-3.68) |
| SGP               | -4.125<br>(-1.14)   | -9.67**<br>(-2.56)    |
| Constant          | 3.383<br>(0.58)     | 18.421***<br>(2.92)   |
| R-squared         | 0.312               | 0.391                 |
| F-test            | 37.106              | 22.161                |

\*\*\*  $p < .01$ , \*\*  $p < .05$ , \*  $p < .1$

Notes: In parentheses is the "t" value

Source: Data processed, 2026

Among the control variables, ROA exhibits a negative and statistically significant coefficient ( $\beta = -100.019$ ;  $t = -2.57$ ;  $p < 0.05$ ), whereas ROE shows a positive and statistically significant coefficient ( $\beta = 44.296$ ;  $t = 4.95$ ;  $p < 0.01$ ) with environmental innovation. In addition, the Altman Z-Score (ZS) is negatively associated with environmental innovation ( $\beta = -2.406$ ;  $t = -3.02$ ;  $p < 0.01$ ). Conversely, GDP Growth does not display a statistically significant relationship with environmental innovation ( $\beta = -0.160$ ;  $t = -0.53$ ;  $p > 0.05$ ), indicating that differences in macroeconomic growth across the observed countries do not significantly explain firms' environmental innovation performance.

The estimated country dummy variables further reveal differences in environmental innovation among the ASEAN-3 countries. Using Indonesia as the reference category, firms located in Malaysia exhibit significantly lower environmental innovation in both Model (1) ( $\beta = -8.313$ ;  $t = -2.46$ ;  $p < 0.05$ ) and Model (2) ( $\beta = -12.402$ ;  $t = -3.68$ ;  $p < 0.01$ ). Similarly, the coefficient for Singapore is statistically insignificant in Model (1) but becomes negative and statistically significant after the inclusion of the control variables in Model (2) ( $\beta = -9.670$ ;  $t = -2.56$ ;  $p < 0.05$ ). These findings indicate that cross-country differences in environmental innovation become more evident after accounting for firm-specific financial characteristics.

The regression model's explanatory ability is also enhanced by the control variables. The extended model explains around 39.1% of the variation in environmental innovation, according to the R-squared, which rises from 0.312 in Model (1) to 0.391 in Model (2). Furthermore, both models are statistically significant based on the overall F-test, with values of 37.106 and 22.161, respectively ( $p < 0.01$ ), indicating that the explanatory variables jointly provide a statistically significant explanation of firms' environmental innovation performance (Khanchel et al., 2023).

The regression results presented in Table 11 examine whether capital expenditure (CAPEX), measured as CAPEX relative to total assets, is associated with environmental innovation (EI). The analysis is presented in two specifications: Model (1) estimates the direct association between CAPEX and EI, while Model (2) incorporates the financial, macroeconomic, and country-level control variables. This specification allows the robustness of the CAPEX–environmental innovation relationship to be assessed after accounting for other factors that may influence firms' environmental innovation performance.

CAPEX is negatively associated with environmental innovation, although the relationship becomes statistically significant only after the control variables are included, according to Table 11's regression results. In Model (1), CAPEX records a negative coefficient of  $-55.068$ , but the relationship is not statistically significant ( $t = -1.16$ ). The coefficient remains negative and becomes statistically significant after the control variables are included in Model (2), with a coefficient of  $-115.279$  ( $t = -2.54$ ;  $p < 0.05$ ). After adjusting for firm-specific financial factors, macroeconomic conditions, and country-specific effects, the negative and significant coefficient in Model (2) suggests that higher capital expenditure intensity is associated with lower levels of environmental innovation.

Among the control variables, ROE shows a positive and statistically significant influence on environmental innovation ( $\beta = 67.621$ ;  $t = 7.69$ ;  $p < 0.01$ ), suggesting that firms with higher returns to shareholders may have greater incentives and capacity to support innovation activities. In contrast, ROA shows a negative and statistically significant association with environmental innovation ( $\beta = -146.229$ ;  $t = -4.55$ ;  $p < 0.01$ ). This finding suggests that higher asset profitability does not necessarily translate into greater environmental innovation. From a resource allocation perspective, firms with higher returns

from existing assets may prioritize investments that generate more immediate or predictable financial returns rather than environmental innovation, which typically involves higher uncertainty and longer payback periods (Bower, 2018). Likewise, there is a negative relationship between environmental innovation and the Altman Z-Score (ZS) ( $\beta = -2.831$ ;  $t = -3.97$ ;  $p < 0.01$ ). This result indicates that financially more stable firms do not necessarily allocate greater resources to environmental innovation, suggesting that financial strength alone may not be sufficient to encourage environmental innovation. From a resource allocation perspective, the availability of financial resources does not automatically ensure their allocation toward environmental objectives, as firms must make strategic choices regarding how resources are deployed across competing priorities (Bower, 2018). On the other hand, GDP growth shows no statistically significant relationship with environmental innovation ( $\beta = 0.191$ ;  $t = 0.53$ ;  $p > 0.05$ ), suggesting that firm-level financial and strategic considerations may be more directly relevant to environmental innovation than broader macroeconomic growth conditions.

**Table 11. Regression Test of CAPEX to Environmental Innovation**

| EI                | (1)                  | (2)                    |
|-------------------|----------------------|------------------------|
| CAPEX             | -55.068<br>(-1.16)   | -115.279**<br>(-2.54)  |
| ROA               |                      | -146.229***<br>(-4.55) |
| ROE               |                      | 67.621***<br>(7.69)    |
| ZS                |                      | -2.831***<br>(-3.97)   |
| GDP               |                      | .191<br>(0.53)         |
| Country: base IDN |                      |                        |
| MLY               | -8.402**<br>(-2.33)  | -13.706***<br>(-4.44)  |
| SGP               | -9.038**<br>(-2.23)  | -15.867***<br>(-4.06)  |
| Constant          | 59.174***<br>(17.80) | 70.962***<br>(16.90)   |
| R-squared         | 0.024                | 0.198                  |
| F-test            | 2.804                | 14.681                 |

\*\*\*  $p < .01$ , \*\*  $p < .05$ , \*  $p < .1$

Notes: In parentheses is the “t” value

Source: Data processed, 2026

The country dummy variables also reveal differences in environmental innovation across the ASEAN-3 countries. Relative to Indonesia as the reference category, firms operating in Malaysia exhibit significantly lower environmental innovation in both Model (1) ( $\beta = -8.402$ ;  $t = -2.33$ ;  $p < 0.05$ ) and Model (2) ( $\beta = -13.706$ ;  $t = -4.44$ ;  $p < 0.01$ ). Likewise, firms in Singapore exhibit lower levels of environmental innovation than those in Indonesia, with the coefficients being statistically significant in both Model (1) ( $\beta = -9.038$ ;  $t = -2.23$ ;  $p < 0.05$ ) and Model (2) ( $\beta = -15.867$ ;  $t = -4.06$ ;  $p < 0.01$ ). These findings indicate that the observed cross-country differences remain robust after accounting for firm-level financial characteristics.

The explanatory capability of the regression model increases once the control variables are added, with the R-squared increasing from 0.024 in Model (1) to 0.198 in Model (2). Additionally, the overall regression model shows greater statistical significance after the inclusion of the control variables, indicating that the broader model accounts for a larger share of the differences in environmental innovation and that the explanatory variables collectively contribute to explaining firms' environmental innovation performance (Khanchel et al., 2023).

The results of the Random Effects panel regression analysis examining whether CAPEX moderates the relationship between ESG performance and Environmental Innovation (EI) are presented in Table 12. Four regression models were estimated to assess both the direct and moderating effects. Models (1) and (2) examine the relationship between CAPEX and environmental innovation without and with control variables, respectively, while Models (3) and (4) incorporate the interaction term between ESG and CAPEX to assess the moderating effect. Based on the panel model specification tests, the Random Effects estimator was selected as the appropriate estimation method (Baltagi, 2021).

**Table 12. Moderation Test**

| EI                | (1)                  | (2)                    | (3)                   | (4)                    |
|-------------------|----------------------|------------------------|-----------------------|------------------------|
| ESG               |                      |                        | .865***<br>(5.58)     | .737***<br>(4.87)      |
| CAPEX             |                      |                        | 314.367<br>(1.13)     | 339.379<br>(1.37)      |
| (ESG x CAPEX)     | -.183<br>(-0.26)     | -1.279*<br>(-1.89)     | -5.855<br>(-1.38)     | -7.035*<br>(-1.88)     |
| ROA               |                      | -152.043***<br>(-4.53) |                       | -135.708***<br>(-4.12) |
| ROE               |                      | 67.83***<br>(7.32)     |                       | 58.823***<br>(6.94)    |
| ZS                |                      | -2.704***<br>(-3.80)   |                       | -1.803**<br>(-2.34)    |
| GDP               |                      | .212<br>(0.59)         |                       | .056<br>(0.16)         |
| Country: base IDN |                      |                        |                       |                        |
| MLY               | -8.191**<br>(-2.23)  | -13.368***<br>(-4.26)  | -11.645***<br>(-3.40) | -15.03***<br>(-4.91)   |
| SGP               | -8.195**<br>(-2.02)  | -15.341***<br>(-3.92)  | -4.363<br>(-1.10)     | -10.304**<br>(-2.51)   |
| Constant          | 57.043***<br>(17.73) | 69.161***<br>(16.91)   | 5.128<br>(0.51)       | 21.827**<br>(2.00)     |
| R-squared         | 0.019                | 0.188                  | 0.160                 | 0.274                  |
| F-test            | 2.104                | 14.176                 | 11.606                | 18.005                 |

\*\*\*  $p < .01$ , \*\*  $p < .05$ , \*  $p < .1$

Notes: In parentheses is the "t" value

Source: Data processed, 2026

The results indicate that ESG has a positive and statistically significant relationship with environmental innovation in both moderation models. In Model (3), ESG has a coefficient of 0.865 ( $t = 5.58$ ;  $p < 0.01$ ), while in Model (4), the coefficient is 0.737 ( $t = 4.87$ ;  $p < 0.01$ ). This finding indicates that firms with stronger ESG performance tend to demonstrate higher levels of environmental innovation, even after the interaction term and control variables are incorporated into the models. Regarding CAPEX, the results show that its direct effect is not statistically significant in either moderation model. In Model (3),

CAPEX has a coefficient of 314.367 ( $t = 1.13$ ;  $p > 0.10$ ), while in Model (4), the coefficient is 339.379 ( $t = 1.37$ ;  $p > 0.10$ ). These results suggest that CAPEX alone does not significantly explain variations in environmental innovation after ESG performance and other factors are considered.

The interaction between ESG and CAPEX provides evidence of a negative moderating effect. The interaction coefficient is  $-5.855$  ( $t = -1.38$ ;  $p > 0.10$ ) in Model (3) and becomes negative and statistically significant in Model (4), with a coefficient of  $-7.035$  ( $t = -1.88$ ;  $p < 0.10$ ). This finding indicates that higher CAPEX tends to weaken the positive relationship between ESG performance and environmental innovation when firm-level financial, macroeconomic, and country-specific controls are included. From a resource allocation perspective, this result suggests that increasing capital expenditure does not necessarily strengthen the conversion of ESG commitments into environmental innovation. Instead, the allocation of capital resources across competing investment priorities may influence the extent to which firms can translate ESG-oriented commitments into environmental innovation, particularly when such allocation is not sufficiently aligned with environmental objectives (Bower, 2018). Thus, the effectiveness of ESG performance in promoting environmental innovation depends not only on the availability of investment resources but also on how those resources are allocated.

Among the control variables, ROA shows a negative and statistically significant relationship with environmental innovation in Model (4) ( $\beta = -135.708$ ;  $t = -4.12$ ;  $p < 0.01$ ), whereas ROE has a positive and statistically significant relationship ( $\beta = 58.823$ ;  $t = 6.94$ ;  $p < 0.01$ ). The Altman Z-Score (ZS) also exhibits a negative and statistically significant relationship with environmental innovation ( $\beta = -1.803$ ;  $t = -2.34$ ;  $p < 0.05$ ). These findings are consistent with the previous results and suggest that firm-level financial characteristics may influence environmental innovation differently depending on how financial resources are generated and allocated. Meanwhile, GDP growth remains statistically insignificant ( $\beta = 0.056$ ;  $t = 0.16$ ;  $p > 0.10$ ), indicating that broader economic growth conditions do not significantly explain variations in environmental innovation within the estimated model.

The country dummy variables also indicate persistent differences in environmental innovation across the ASEAN-3 countries. Relative to Indonesia as the reference category, firms in Malaysia exhibit significantly lower levels of environmental innovation in both Model (3) ( $\beta = -11.645$ ;  $t = -3.40$ ;  $p < 0.01$ ) and Model (4) ( $\beta = -15.030$ ;  $t = -4.91$ ;  $p < 0.01$ ). For Singapore, the coefficient is negative but statistically insignificant in Model (3) ( $\beta = -4.363$ ;  $t = -1.10$ ;  $p > 0.10$ ), while it becomes statistically significant in Model (4) ( $\beta = -10.304$ ;  $t = -2.51$ ;  $p < 0.05$ ). These results indicate that cross-country differences remain evident after accounting for the moderating effect of CAPEX and other firm-level characteristics.

The explanatory power of the model also improves after the inclusion of the control variables, with the R-squared increasing from 0.160 in Model (3) to 0.274 in Model (4). The F-statistics of 11.606 and 18.005 indicate that both models are jointly significant. More importantly, the negative and statistically significant interaction term in Model (4) indicates that CAPEX weakens the positive relationship between ESG performance and environmental innovation, supporting H4. To further interpret this moderating effect, a marginal-effects analysis was conducted at different levels of CAPEX, with the results presented in Table 13.

**Table 13. Marginal Effects of ESG on Environmental Innovation at Different Levels of CAPEX**

| CAPEX Level  | CAPEX/TA | Marginal Effect | Std. Error | z     | p-value | 95% CI      |
|--------------|----------|-----------------|------------|-------|---------|-------------|
| Low (P25)    | 0.0155   | 0.923           | 0.126      | 0.140 | 0.000   | 0.677–1.170 |
| Medium (P50) | 0.0318   | 0.752           | 0.119      | 6.30  | 0.000   | 0.518–0.986 |
| High (P75)   | 0.0545   | 0.513           | 0.140      | 3.66  | 0.000   | 0.238–0.788 |

Source: Data processed, 2026

The marginal-effects analysis provides further evidence of the negative moderating effect of CAPEX. The positive effect of ESG on environmental innovation decreases from 0.923 at a low level of CAPEX (P25) to 0.752 at the median level (P50) and 0.513 at a high level (P75), while remaining statistically significant at all three levels ( $p < 0.001$ ). This declining pattern indicates that higher CAPEX attenuates the positive effect of ESG on environmental innovation, providing further support for H4.

To assess the robustness of the main findings, a supplementary regression analysis was conducted using an alternative model specification while retaining the key explanatory, moderating, and control variables. As reported in Table 14, the robustness results reveal some differences in the direct effects of ESG and CAPEX compared with the main regression models. These differences are important because they indicate that the individual coefficients of ESG and CAPEX are sensitive to the alternative model specification. However, the central moderating relationship remains stable across specifications (Drukker, 2003).

**Table 14. Robustness Test**

| EI              | Coef  | std. err. | t     | P> t |
|-----------------|-------|-----------|-------|------|
| ESG             | .003  | .009      | 0.34  | .736 |
| CAPEX           | 15.1  | 7.676     | 1.97  | .049 |
| E               | .024  | .006      | 3.88  | 0    |
| (ESG x CAPEX)   | -.245 | .108      | -2.27 | .023 |
| ROA             | -.146 | .728      | -0.20 | .841 |
| ROE             | .307  | .208      | 1.48  | .14  |
| ZS              | -.02  | .024      | -0.82 | .411 |
| GDP             | -.001 | .005      | -0.28 | .779 |
| country_id: IDN |       |           |       |      |
| MLY             | -.201 | .147      | -1.37 | .172 |
| SGP             | -.136 | .191      | -0.71 | .478 |
| cons            | 2.239 | .451      | 4.96  | 0    |

Source: Data processed, 2026

In the robustness specification, ESG has a positive but statistically insignificant relationship with environmental innovation ( $\beta = 0.003$ ;  $t = 0.34$ ;  $p = 0.736$ ), whereas CAPEX exhibits a positive and statistically significant relationship with environmental innovation ( $\beta = 15.100$ ;  $t = 1.97$ ;  $p = 0.049$ ). These results differ from the main analysis, where the direct effects of ESG and CAPEX were estimated under the primary model specification. Such differences may arise because the inclusion of the interaction term changes the interpretation of the lower-order coefficients and because the alternative specification captures the conditional nature of the ESG–environmental innovation relationship more explicitly. Therefore, the direct coefficients of ESG and CAPEX should not be interpreted independently of the interaction term.

Importantly, the interaction between ESG and CAPEX remains negative and statistically significant ( $\beta = -0.245$ ;  $t = -2.27$ ;  $p = 0.023$ ). This result is consistent with the main moderation analysis and indicates that higher CAPEX weakens the positive relationship between ESG performance and environmental innovation. Thus, although the signs and statistical significance of the direct ESG and CAPEX coefficients change under the alternative specification, the key moderating effect remains negative and statistically significant. This persistence provides stronger evidence that the central finding concerning the moderating role of CAPEX is not driven solely by the primary model specification.

The control variables do not exhibit statistically significant relationships with environmental innovation in the robustness specification. ROA, ROE, ZS, and GDP Growth are all statistically insignificant, while the country dummy variables for Malaysia and Singapore are also statistically insignificant relative to Indonesia. Overall, the robustness analysis provides partial rather than complete confirmation of the main results: the direct effects of ESG and CAPEX are sensitive to the alternative specification, but the negative and significant  $\text{ESG} \times \text{CAPEX}$  interaction remains stable. This strengthens confidence in the conclusion that CAPEX moderates the ESG–environmental innovation relationship by weakening the positive effect of ESG on environmental innovation.

This research explores the connections between ESG performance, the Environmental Pillar (E), CAPEX, and Environmental Innovation (EI) for publicly traded firms in Indonesia, Malaysia, and Singapore. The overall results indicate that ESG—especially its environmental component—has a beneficial effect on environmental innovation, while CAPEX has a detrimental impact, diminishing ESG's positive effect. In addition, notable variations in environmental innovation are found among the three ASEAN nations. These results enhance the existing body of knowledge on sustainable corporate practices by highlighting that merely making investment choices is not enough to foster environmental innovation unless these choices are effectively integrated with sustainability goals. Table 15 shows all supported hypotheses based on the results described earlier.

The first finding indicates that ESG positively affects environmental innovation, supporting the growing consensus that sustainability-oriented corporate practices stimulate firms' innovation capabilities. This result supports Hypothesis 1 (H1). A company's dedication to incorporating environmental, social, and governance factors into strategic management is reflected in its ESG implementation (Frag, 2025). Businesses are encouraged to invest in sustainable product development, eco-friendly technologies, and cleaner production methods as a result of this integration (Zhao et al., 2023). This discovery aligns with the Resource-Based View (RBV), which posits that a company's abilities, expertise, and management frameworks serve as essential strategic assets that can lead to enduring competitive edges (Barney, 1991). ESG practices strengthen these capabilities by improving managerial quality, stakeholder engagement, organizational learning, and risk management, all of which facilitate innovation activities (Yu et al., 2025).

The Natural Resource-Based View (NRBV) put forth by (Hart, 1995), which expands RBV by highlighting environmental capabilities as strategic resources, is also supported by the positive correlation between ESG and environmental innovation. According to NRBV, firms that proactively invest in environmental management develop superior capabilities for pollution prevention, resource efficiency, and sustainable product development (Hart, 1995; McDougall et al., 2022). These capabilities ultimately translate into stronger environmental innovation performance. Stakeholder Theory also clarifies that companies are under growing demands from investors, regulatory bodies, customers, and the community to enhance their

sustainability efforts (Sulkowski et al., 2018). Responding to these pressures encourages firms to introduce innovative environmental solutions that satisfy stakeholder expectations while maintaining corporate legitimacy.

**Table 15. Hypothesis Test**

| Hypothesis | Model   | Coefficient           | t-value | Decision                        |
|------------|---------|-----------------------|---------|---------------------------------|
| H1         | Model 2 | 0.504***              | 4.62    | Supported                       |
| H2         | Model 2 | 0.739***              | 9.24    | Supported                       |
| H3         | Model 2 | -115.279**            | -2.54   | Supported                       |
| H4         | Model 4 | -7.035*               | -1.88   | Supported (Negative Moderation) |
| H5         | Model 4 | Malaysia = -15.030*** | -4.91   | Supported                       |
|            |         | Singapore = -10.304** | -2.51   |                                 |

Source: Data processed, 2026

The empirical findings are consistent with previous studies. (Xie et al., 2019) demonstrated that environmental management practices significantly improve green process and product innovation. (Broadstock et al., 2021) found that firms with superior ESG performance exhibit greater innovation capability due to stronger governance quality and more efficient resource allocation. Similarly, (Hou et al., 2025) concluded that ESG performance promotes green technological innovation through enhanced organizational capabilities and stakeholder collaboration. Collectively, these studies reinforce the argument that ESG functions not merely as a disclosure mechanism but as an important driver of sustainable innovation.

The second discovery shows that the Environmental Pillar has an even greater beneficial impact on environmental innovation than the total ESG score. These results suggest that Hypothesis 2 (H2) is supported. Compared with ESG, the environmental dimension focuses directly on firms' environmental policies, carbon emissions, energy efficiency, waste management, and resource conservation (Patil et al., 2021). Consequently, improvements in environmental performance are more closely associated with environmental innovation activities. This result aligns with the Porter Hypothesis, which suggests that environmental rules and proactive management of the environment encourage technological advancements that enhance both ecological and economic outcomes (Porter & Linde, 1995). Firms that actively pursue environmental initiatives often redesign production systems, develop eco-friendly products, and improve operational efficiency, thereby increasing innovation outcomes. Previous studies similarly reported that environmental management practices directly stimulate green innovation and enhance firms' long-term competitiveness (Albitar et al., 2024; X. Xie et al., 2019).

The third finding demonstrates that Capital Expenditure negatively affects environmental innovation, indicating that greater investment in physical assets does not necessarily translate into stronger environmental innovation. These results suggest that Hypothesis 3 (H3) is supported. This finding suggests that many firms within ASEAN-3 continue to allocate capital expenditure primarily toward production expansion, operational capacity, or conventional infrastructure rather than environmentally sustainable technologies (Nepal et al., 2021). Such investment priorities may improve production efficiency without substantially contributing to environmental innovation (Khalil & Nimmanunta, 2023). This outcome is in line with research that contends that capital investment only fosters green innovation when it is specifically focused on eco-friendly technologies (D'Amato et al., 2021).

Therefore, the effectiveness of CAPEX depends not only on the amount invested but also on the strategic allocation of investment resources.

The moderation analysis indicates that CAPEX weakens the positive relationship between ESG performance and environmental innovation. Although stronger ESG performance remains positively associated with environmental innovation, the negative interaction effect indicates that this positive relationship becomes weaker as CAPEX increases. The marginal effects analysis further supports this finding, showing that the positive effect of ESG on environmental innovation declines consistently across low, medium, and high levels of CAPEX. Thus, the findings support Hypothesis 4 (H4), indicating that higher capital expenditure reduces the strength of the positive ESG–environmental innovation relationship. This suggests that capital expenditure does not automatically enhance the innovation benefits associated with ESG performance, particularly when investment resources are not sufficiently aligned with sustainability-oriented technologies and processes (Cohen et al., 2026; Jain, 2026). Therefore, investment expansion alone may not be sufficient to strengthen environmental innovation, highlighting the importance of aligning capital allocation decisions with environmental objectives. Consistent with this perspective, sustainability-oriented investment strategies are more likely to generate innovation benefits when firms deliberately integrate environmental considerations into their investment decisions (Flammer, 2023).

The final finding indicates significant cross-country differences in environmental innovation among ASEAN-3 firms. In contrast to Indonesia, companies functioning in Malaysia and Singapore demonstrate reduced degrees of environmental innovation once firm traits and economic factors are taken into account. This result answers Hypothesis 5 (H5). These differences may reflect variations in industrial structures, environmental regulations, ESG implementation, and corporate investment priorities across countries. Indonesia has experienced substantial growth in mandatory sustainability reporting, green finance initiatives, and environmental disclosure requirements over recent years, encouraging firms to increase their environmental innovation efforts (Prihandono & S. Yuniarti, 2023; Supriyanto et al., 2025). Meanwhile, firms in Malaysia and Singapore may allocate greater investment toward technological efficiency or international competitiveness that is not fully captured by the environmental innovation indicator employed in this study (Ong et al., 2019; Wenlong et al., 2022). These findings support the argument of Institutional Theory (DiMaggio and Powell, 1983), which posits that institutional environment—including government regulations, market pressures, and societal expectations—shape firms' strategic responses to sustainability and innovation.

In summary, this research adds to the existing body of knowledge on ESG and sustainability by showing that environmental advancements are influenced by both the performance in sustainability and the financial choices made by corporations, as well as the surrounding institutional environment. ESG and environmental performance are important drivers of environmental innovation, while the effectiveness of capital expenditure in supporting environmental innovation may depend on the extent to which investment resources are aligned with environmental objectives. The findings therefore emphasize that firms should align capital allocation with sustainability strategies to maximize innovation outcomes. For policymakers, the results suggest that strengthening ESG regulations alone may be insufficient unless accompanied by incentives encouraging firms to channel capital investments toward environmentally friendly technologies. Such policy alignment will be essential for supporting sustainable industrial transformation across the ASEAN region.

## CONCLUSIONS

This research investigated the effects of ESG performance, the Environmental Pillar (E), and CAPEX on Environmental Innovation (EI) in publicly traded firms within the ASEAN-3 area, which includes Indonesia, Malaysia, and Singapore. This study provides empirical results about the connection between corporate investment decisions in promoting environmental innovation and sustainability performance using panel data regression with a Random Effects Model. The research results show multiple significant conclusions. First, environmental innovation is positively and significantly impacted by ESG performance, suggesting that companies with more robust sustainability initiatives have a greater tendency to create environmentally friendly products, adopt cleaner methods of production, and develop sustainable technologies. This result verifies that ESG serves not only as a framework for sustainability reporting but also as a strategic asset that boosts the innovation potential of companies (Cohen et al., 2026; Nepal et al., 2021). Second, the environmental pillar demonstrates a stronger positive influence on environmental innovation than the overall ESG score. This result suggests that environmental-related corporate initiatives—including carbon management, resource efficiency, waste reduction, and environmental policies—represent the most influential ESG dimension in stimulating environmental innovation. Consequently, firms that emphasize environmental responsibility are better positioned to translate sustainability commitments into innovative outcomes. Third, CAPEX exhibits a significant negative relationship with environmental innovation. This finding implies that capital investment alone does not necessarily support sustainability-oriented innovation, as its contribution to environmental innovation may depend on the alignment between investment allocation and environmental objectives. Therefore, the effectiveness of CAPEX depends largely on the strategic orientation of investment rather than its magnitude (Mirza et al., 2024). Fourth, the analysis of moderation shows that spending on capital reduces the beneficial impact of ESG on environmental innovation. This finding suggests that organizations that excel in ESG may still see diminished innovation advantages when their investment choices focus more on conventional physical assets rather than on green technologies. Accordingly, sustainability performance and investment strategy should be integrated rather than implemented independently (Supriyanto et al., 2025). Finally, this study identifies significant differences in environmental innovation across ASEAN-3 countries. Relative to Indonesia, firms operating in Malaysia and Singapore exhibit lower levels of environmental innovation after controlling for firm-specific characteristics. These differences suggest that institutional environments, sustainability regulations, corporate investment priorities, and national innovation ecosystems continue to shape firms' environmental innovation performance (Ong et al., 2019; Prihandono & S. Yuniarti, 2023; Supriyanto et al., 2025; Wenlong et al., 2022).

From a theoretical perspective, this study extends the Resource-Based View, Natural Resource-Based View, Stakeholder Theory, and Institutional Theory by demonstrating that sustainability performance alone is insufficient to maximize environmental innovation unless accompanied by appropriate investment allocation. From a pragmatic point of view, the results highlight the importance for managers to coordinate financial investment choices with enduring sustainability plans, whereas lawmakers ought to support ESG rules by providing incentives that motivate companies to invest in eco-friendly technologies. Even with these contributions, some limitations must be recognized. To begin with, this research concentrates exclusively on publicly traded firms in three ASEAN nations, which restricts the applicability of the results to alternative emerging or developed markets. Additionally, environmental

innovation is assessed through one secondary metric sourced from the Refinitiv ESG database, which might not encompass all facets of companies' innovative efforts. Furthermore, capital expenditure is evaluated via a financial ratio that fails to differentiate between environmentally friendly investments and traditional investments, rendering it unfeasible to pinpoint the exact distribution of corporate capital spending. Future research is encouraged to expand the geographical coverage by including additional ASEAN countries or conducting cross-regional comparisons between emerging and developed economies. Researchers could also consider alternative indicators of environmental innovation, including green patents, environmental R&D spending, or green technology adoption, to offer a more thorough evaluation of innovation performance. Additionally, future research should differentiate between green capital expenditure and traditional capital spending to better understand how varying investment types impact environmental innovation. Lastly, employing advanced econometric methods like dynamic panel estimation, System-GMM, or threshold regression can yield more profound insights into the long-term and nonlinear relationships among ESG performance, investment choices, and environmental innovation.

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