THE ROLE OF THE BOARD OF DIRECTORS' GENDER DIVERSITY MODERATION IN THE RELATIONSHIP BETWEEN CARBON EMISSIONS AND ESG PERFORMANCE

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Abstract

This study examines the relationship between corporate carbon emissions and environmental, social, and governance (ESG) performance while evaluating the moderating influence of board gender diversity within Indonesia's regulatory environment. Drawing on resource dependence theory (RDT), the analysis positions board composition as a strategic governance mechanism through which firms secure essential resources, including stakeholder legitimacy, environmental expertise, and enhanced oversight, to respond to sustainability pressures. Using panel data from publicly listed firms between 2014 and 2024 and employing fixed effects and lagged regression models, the findings show a positive association between carbon emissions and subsequent ESG performance, indicating that firms with higher environmental exposure tend to strengthen their sustainability disclosures. Although board gender diversity does not directly affect ESG outcomes, it reinforces governance structures that enable more transparent and accountable environmental practices. The study highlights limitations within Indonesia's compliance-oriented ESG framework and underscores the need for governance-focused reforms to improve the credibility and effectiveness of sustainability reporting.

Keywords: Board Gender Diversity, Carbon Emissions, Corporate Governance, ESG Performance, Resource Dependence Theory (RDT)

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1. INTRODUCTION

In conjunction with escalating global concerns over climate and the environment, the notion of sustainable development has garnered extensive and considerable widespread interest across numerous nations (Chen & Wang, 2024; Li et al., 2025). These issues stem from heightened energy use, elevated carbon emissions, and substantial risks to climate, biodiversity, and the natural environment (Chen & Wang, 2024; Wang et al., 2021). In the contemporary global economy, this issue exerts significant pressure on the corporate sector to adopt a more transparent and socially responsible company model. Contemporary companies prioritise not only their financial performance but also the incorporation of ecologically sustainable methods (Aly et al., 2024; Xing et al., 2025). The correlation between carbon emissions and environmental, social, and governance (ESG) performance indicates that elevated carbon emissions suggest a lack of environmentally sustainable practices, potentially diminishing the company's successful image and adversely affecting its ESG standing (Chen & Wang, 2024; Li et al., 2025).

The apprehensions will escalate if the prevailing environmental issues persist, as they may threaten the existence of both present and future generations (García Martín & Herrero, 2020; Grau Grau et al., 2024). The public demands that firms assume accountability for their environmentally and socially harmful practices (Palantza et al., 2023; Al Amosh & Khatib, 2023). Pressure from diverse stakeholders, particularly institutional investors and regulatory bodies that emphasise sustainability in corporate governance, has increasingly compelled firms to implement a more transparent ESG reporting framework to bolster stakeholder confidence (Fu et al., 2025).

In reaction to these demands, Asian countries, particularly China, have included sustainable development into their national strategies (Chen & Wang, 2024; Thanasas et al., 2023). Since September 2020, China has established an ambitious "double carbon" objective, significantly impacting regional economic development (Chen & Wang, 2024; Qin et al., 2024). In response, governments are actively engaged in formulating novel policies and strategies tailored to local capabilities to facilitate carbon emission reduction (Chen & Wang, 2024).

In Indonesia, the growing emphasis on sustainability and ESG disclosure reflects the nation's increasing alignment with global efforts to promote environmentally responsible and transparent business practices (Prihandini, 2024). The Financial Services Authority (*Otoritas Jasa Keuangan,* OJK) has introduced pivotal regulations, including POJK No. 51/POJK.03/2017 on sustainable finance and POJK No. 17 of 2023 on sustainability reporting, which mandate publicly listed firms to disclose their ESG performance in a systematic manner (Sari et al., 2025; Bayuaji et al., 2025). Nevertheless, the level of compliance and the quality of ESG reporting among Indonesian companies remain inconsistent, as many organizations continue to emphasize administrative compliance rather than substantive integration of sustainability principles (Prihandini, 2024). Furthermore, female representation on corporate boards in Indonesia remains relatively low compared to that of developed economies, which may hinder the effectiveness of corporate governance in fostering transparency and sustainable business conduct (Pernamasari, 2025; Alahdal et al., 2024). These contextual conditions highlight the importance of examining the moderating role of board gender diversity, strengthening the relationship between carbon emissions and ESG performance, particularly within the context of developing economies such as Indonesia that are transitioning toward a low-carbon future (Itan et al., 2025; Pernamasari, 2025).

Despite the inclusion of carbon emissions within the environmental pillar of the ESG framework, existing literature frequently indicates that ESG scores are predominantly a function of disclosure quality rather than actual, substantive environmental performance (Abdullah et al., 2025). This observation implies that firms can attain superior ESG ratings notwithstanding persistently high levels of carbon emissions, underscoring a critical disconnect between the quality of environmental reporting and genuine ecological impact (Abdullah et al., 2025). Accordingly, adopting carbon emissions as a distinct analytical construct is essential (Baratta et al., 2023). This methodological separation serves to clearly delineate between more symbolic disclosure and verifiable environmental outcomes, thereby mitigating potential conceptual redundancy when investigating the complex relationship between holistic ESG performance and specific carbon output (Baratta et al., 2023).

Gender diversity in corporate leadership is regarded as a governance feature that strategically contributes to efforts aimed at reducing carbon emissions and enhancing ESG performance (Capuano & Carabelli, 2023; Wang et al., 2024). Organisations with a higher representation of women on boards exhibit greater sensitivity to environmental and social concerns and are perceived as more trustworthy in strategic decision-making (Konadu et al., 2022). Including diverse viewpoints and beliefs from women in leadership roles enables boards of directors to apply greater internal pressure for effective management of environmental risks and consistent implementation of sustainability policies (Nuber & Velte, 2021). The inclusion of women on the board enhances social and environmental awareness, broadens the company's external network, secures resources and strategies, and bolsters public trust, which is essential for attaining the company's long-term sustainability objectives (Peng & Chandarasupsang, 2023; Xing et al., 2025).

In light of this urgency, gender diversity in corporate leadership is increasingly recognised as crucial in advancing sustainability initiatives and enhancing ESG performance. Numerous studies indicate that more diverse boards of directors exhibit greater responsiveness to ESG concerns (Surbakti & Sari, 2024). Considering prior research suggesting that gender diversity on boards influences organisations' ESG practices (Zhu & Chen, 2025). Consequently, women serve not only as a symbol of equality but also as a crucial element in promoting the adoption of corporate governance aimed at sustainable growth (Eissa et al., 2024; Abdullah et al., 2022).

This study uses resource dependence theory (RDT) to elucidate the impact of gender diversity on

the correlation between carbon emissions and ESG performance (de Oliveira Silva, 2023; Odriozola et al., 2024). This idea underscores that enterprises depend on external resources, including regulators, investors, customers, and other stakeholders, who are increasingly concerned with ESG matters (Odriozola et al., 2024). In this setting, the diversity of gender, age, experience, and professional background in management provides many resources that organisations will leverage (Odriozola et al., 2024). The implementation of RDT offers a theoretical framework for elucidating how gender diversity in corporate leadership enhances an organization's capacity to address external pressures, broadens resource accessibility, and elevates social recognition from diverse stakeholders (Chang et al., 2024).

Nevertheless, research directly examining the influence of gender diversity as a moderating factor in the relationship between carbon emissions and ESG performance, particularly in developing nations like Indonesia, remains scarce. This study aims to examine the correlation between carbon emissions and company ESG performance, while investigating how gender diversity on the board of directors enhances these effects within the framework of sustainable governance.

The structure of this paper is as follows. Section 2 reviews the relevant literature and develops the research hypothesis. Section 3 describes the data sources, sample selection, variable definitions, and the empirical methodology employed in this study. Section 4 presents the empirical findings, including descriptive statistics, correlation analysis, and the main regression results. Section 5 discusses the implications of the findings in both theoretical and practical contexts. Finally, Section 6 concludes the paper by summarizing the key results, outlining the limitations, and providing recommendations for future research.

2. LITERATURE REVIEW AND HYPOTHESIS DEVELOPMENT

2.1. Carbon emissions and ESG performance

The empirical and theoretical investigation into the nexus between corporate carbon emissions and holistic ESG performance constitutes a core concern within the domain of corporate sustainability research (Baratta et al., 2023). Carbon emissions are posited as a fundamental metric within the environmental pillar, signifying the effectiveness of a firm's management of its operational ecological footprint (Baratta et al., 2023; Liu et al., 2023). Elevated emissions trajectories are consistently correlated with amplified environmental risk exposure, operational energy inefficiencies, and the prospect of substantial regulatory compliance expenditures (Yu et al., 2025). Conversely, demonstrated proficiency in the mitigation and control of carbon output is interpreted as evidence of a robust and proactive commitment to sustainability protocols (Baratta et al., 2023; Yu et al., 2025). Consequently, the carbon emissions variable is regularly employed as an essential, high-fidelity environmental performance benchmark, forming an indispensable constituent in the comprehensive evaluation of a firm's ESG standing (Yu et al., 2025).

Extensive investigations that utilize quantitative methodologies on favorable outcomes, as shown by the studies Chen and Wang (2024) and Wang and Li (2024), show that reducing carbon emissions substantially improves ESG performance. Nonetheless, the alternative findings shown by Shu and Tan (2023) confirm that carbon emission mitigation or regulation adversely affects non-state-owned enterprises. The impact of environmental legislation differs among organisations based on the resources and institutional support accessible to each entity, highlighting the necessity to improve the efficacy of corporate sustainability programmes (Ying & Jin, 2024).

The divergence in these findings underscores the nuanced mechanisms through which environmental strategies translate into corporate outcomes (Ye & Xu, 2023). Moreover, a substantial body of empirical evidence corroborates the notion that proficiency in carbon emission management critically influences a firm's comprehensive ESG evaluation (Xue et al., 2025). Specifically, corporations characterized by robust transparency in emissions disclosure, the strategic deployment of low-carbon technologies, and the systematic integration of ecological sustainability protocols into their operational governance structures typically attain superior ESG scores (Răpan et al., 2022). This observed correlation underscores that carbon mitigation extends beyond a purely ecological concern, it is intrinsically tied to sound corporate governance practices, effective risk management frameworks, and the enhancement of firm reputation among diverse stakeholders (Chen & Wang, 2024). Consequently, establishing a clear understanding of the carbon emissions ESG performance nexus is indispensable within the sustainability literature for rigorously assessing how a company's proactive environmental strategy contributes to the generation of long-term shareholder value (Chen & Wang, 2024).

2.2. Board gender diversity moderates the impact of carbon emission performance on ESG performance

Prior studies have demonstrated that a high-quality board of directors can promote corporate responsibility in enhancing environmental efficiency (Zara et al., 2023). This facilitates companies in obtaining support from diverse stakeholders (Fayad et al., 2022). Aguilera et al. (2021) asserted that proficient boards of directors and executing environmentally sustainable strategies can diminish carbon emissions and enhance the quality of long-term performance reporting. The degree to which governance systems affect environmental and socioeconomic results is still contested, especially in varying institutional contexts (Pinheiro et al., 2024).

The current gender diversity composition in Indonesian corporate boards, quantified at a value of 0.144, suggests an approximate 85%–14% male to female ratio, denoting a structure considerably removed from full homogeneity (Capuano & Carabelli, 2023; Konadu et al., 2022). This imbalance is highlighted by the observation that most companies feature only a single female director (Odriozola et al., 2024). Methodologically, the Indonesian regulatory framework, specifically Law No. 40 of 2007 concerning Limited Liability

Companies and POJK.04/2014, remains silent on mandatory gender representation percentages, meaning no statutory quotas are currently in force (Sari et al., 2025). Over the past decade, however, the improvement in female board representation has been catalyzed primarily by non-legislative forces, including pressure exerted by institutional investors, favorable evaluations from ESG rating agencies, and various pro-equality initiatives (Sari et al., 2025). Crucially, this progress has been heterogeneous across industrial sectors (Bayuaji et al., 2025). Given the absence of legally binding gender quotas, the observed enhancement in female representation is best characterized as a function of voluntary compliance and adaptation to evolving market demands (Chang et al., 2024). Furthermore, empirical literature substantiates the presence of a critical mass effect, indicating that the splitary presence of a female director often yields negligible influence, with more consequential organizational and strategic shifts materializing only when the number of women on the board reaches two or three individuals (Margaretha & Isnaini, 2014; Moreno-Gómez & Calleja-Blanco, 2018).

RDT elucidates these dynamics by positing that the diversity of gender, age, experience, and professional background within management furnishes organisations with essential resources to address external challenges (de Oliveira Silva, 2023). This is particularly pertinent when firms function within a volatility, uncertainty, complexity, and ambiguity (VUCA) environment that necessitates the adaptation of staff skills and resources to meet market needs (Odriozola et al., 2024; Pitelis & Wang, 2019). In this context, a manager's extensive knowledge enhances the possibility for performance improvement and competitive advantage, as such knowledge is a valuable and complex asset to copy (Faiz et al., 2024). Recent studies indicate that gender diversity fosters creativity within the corporate sector (Sierra-Morán et al., 2024).

Building upon RDT, numerous studies link carbon emission performance to ESG outcomes, emphasising that companies capable of managing emissions are more inclined to cultivate stakeholder trust, mitigate compliance risks, and improve long-term competitiveness (Mansour et al., 2024). Evidence shows that companies adopting energy efficiency, renewable energy, and footprint minimisation often benefit from green financing, governmental support, and customer loyalty (Odriozola et al., 2024). Effective emission management indicates openness in governance, strengthening the social and governance aspects of ESG.

Companies exhibiting exceptional carbon emission performance through energy efficiency, renewable energy adoption, and carbon footprint minimisation can obtain numerous advantages, including enhanced access to green investments, augmented governmental support, and customer loyalty increasingly oriented towards sustainability (Odriozola et al., 2024). Moreover, proficient control of carbon emissions indicates enhanced openness in governance and social responsibility, hence favorably influencing the social and governance dimensions of ESG (Odriozola et al., 2024)

Consequently, according to the RDT, firms proficient in regulating carbon emissions might enhance their market standing by diminishing their reliance on precarious resources, such as fossil fuels or environmentally harmful compounds (Odriozola et al., 2024). This enhances operational efficiency and fortifies connections with stakeholders who increasingly require sustainable business practices, leading to improved ESG performance (Mansour et al., 2024).

In the social domain, women exhibit heightened social awareness (Bhardwaj et al., 2024). Women exhibit considerable care for the environment and actively endeavour to mitigate adverse effects such as pollution (Ismail et al., 2025). Research indicates that women have a heightened aversion to risk and are less inclined to breach financial or ethical standards in their management practices (Al-Shaer et al., 2024). This enhances the company's standing in the capital market, as investors prioritise sustainability in their investment choices. Management teams with increased diversity obtained more favourable assessments due to their improved perspectives in decision-making (Wayne, 2021; Murray, 2025; Hou & Yuan, 2019). They proficiently represent and promote the involvement of diverse stakeholders, exhibit an inclusive leadership style, and uphold exceptional and direct communication with their subordinates (Oussii & Jeriji, 2025).

The inclusion of women on boards of directors enhances ESG and serves as a crucial moderating variable in the correlation between carbon emissions performance and overall ESG achievement.

H1: Board gender diversity moderates the impact of carbon emission performance on ESG performance.

3. RESEARCH METHODOLOGY

Moderated multiple regression (MMR) is a statistical technique used to examine the influence of moderation. In this technique, the variable (moderator) modifies the direction or intensity of the relationship between the predictor variable (*X*) and the dependent variable (*Y*). This model combines the terms interaction (products of independent variables) into regression equations to assess moderation.

The study posits that the board gender diversity (*BGD*) variable functions as a moderator factor, which is hypothesized to increase or decrease the correlation between carbon emissions (*CE*) and *ESG* performance. This interaction is created by multiplying the variables *CE* and *BGD* (*BGD* × *CE*), which are then integrated into the regression equation.

Equation (1) shows the moderated regression model used in this study. Equation (2) presents the moderated regression model with control variables.

$$ESG_{it} = \beta_0 + \beta_1 CE_{it} + \beta_2 BGD_{it} + \beta_3 (BGD_{it} \times CE_{it}) + Country + Year + \varepsilon_{it} \quad (1)$$

$$ESG_{it} = \beta_0 + \beta_1 CE_{it} + \beta_2 BGD_{it} + \beta_3 (BGD_{it} \times CE_{it}) + \beta_4 BSize_{it} + \beta_5 FCF_{it} + \beta_6 ROA_{it} + Country + Year + \varepsilon_{it} \quad (2)$$

where,

- ESG_{it} = ESG performance;
- $\beta_1 CE_{it}$ = carbon emissions;
- $\beta_2 BGD_{it}$ = board gender diversity;
- $\beta_3(BGD_{it} \times CE_{it})$ = board gender diversity × carbon emissions;
- $\beta_4 BSize_{it}$ = board size;
- $\beta_5 FCF_{it}$ = free cash flow;
- $\beta_6 ROA_{it}$ = return on assets.

ESG indicates environmental, social, and governance performance, with metrics sourced from the Bloomberg database, signaling a thorough evaluation of overall ESG performance (Kiran et al., 2024; Mahmood et al., 2025). Carbon emissions (*CE*) are measured by the natural logarithm of total actual CO2 emissions expressed in tons (Alkurdi et al., 2024; Bose et al., 2024; Hasan & Chen, 2025). Board size (*BSize*) indicates the number of directors on the company's board (Alkurdi et al., 2024; Chatjuthamard et al., 2022; Schoonjans, 2024). Free cash flow (*FCF*) indicates the company's unencumbered cash flow (Alkurdi et al., 2024; Arianpoor & Mohammadbeikzade, 2025; Kalash, 2024). Return on assets (*ROA*) is the ratio of net profit to total assets (Alkurdi et al., 2024; Chung & Wang, 2020; EL-Ansary & Al-Gazzar, 2021). Board gender diversity (*BGD*) shows the ratio of female directors on the company's board of directors (Alkurdi et al., 2024; Githaiga, 2024).

The variables *ROA* and cash flow (*FCF*) were incorporated as essential control variables, serving to proxy for a firm's inherent financial capacity to fund environmental and social initiatives, a justification consistent with their frequent adoption across the broader ESG literature (Alkurdi et al., 2024). While the inclusion of these financial metrics carries the potential risk of endogeneity, primarily stemming from the potential for bidirectional causality between corporate financial performance and ESG outcomes, their presence is nevertheless methodologically imperative (Alkurdi et al., 2024). Their inclusion ensures that observed effects are not merely artifacts of unmitigated heterogeneity arising from differences in a firm's baseline financial conditions, thereby mitigating potential omitted variable bias (Schoonjans, 2024).

To address this structural endogenity concern, two primary mitigation strategies were employed. First, a fixed effect model was utilized to effectively absorb time-invariant, unobserved firm-specific characteristics (Alkurdi et al., 2024). Second, time lag analysis was implemented to minimize the risk of reverse causality (Odriozola et al., 2024). Although sophisticated econometric techniques, such as instrumental variables (IVs), the sample consists of publicly listed firms observed during the period 2014–2024, after excluding financial institutions and firms with incomplete governance or financial data (Kılıç & Kuzey, 2016). The final dataset comprises 809 firm-year observations, providing sufficient variation in board gender diversity to support the use of IVs (Kılıç & Kuzey, 2016). It was initially evaluated, but ultimately dismissed due to the stringent requirement for, and practical unavailability of, suitable and valid IVs within the current data context. Consequently, the combination of the fixed effects specification and time-lagged modeling represents the most feasible and methodologically sound approach for robust inference (Alkurdi et al., 2024; Odriozola et al., 2024).

This study uses a quantitative methodology to evaluate the hypothesis (Lin et al., 2020). Quantitative research is a methodology that relies on data collection through statistical tools for data analysis (Lin et al., 2020). This study uses secondary data, particularly panel data from the Indonesia Stock Exchange (IDX), Bloomberg, and Osiris. The population will consist of all permanent members from 2014 to 2024. In ten years, the total calculation will amount to 627.

Chen et al. (2023) affirm that *ROA* evaluates a company's capacity to earn revenue from its assets. Equation (3) shows the formula used to calculate *ROA*:

$$\frac{Total\ assets}{Net\ profit\ after\ tax} \times 100\% \quad (3)$$

Profitability signifies the efficacy of management in generating profits by making optimal use of all available resources (Alghizzawi et al., 2022). The size of the board indicates the number of directors on the company's board (Setiani & Novitasari, 2024). The size of the board is determined by counting all the members involved in strategic decision-making, including the executive director responsible for day-to-day operations and the commissioner or independent board member in charge of overseeing (Issa & In'airat, 2024).

Alandejani and Al-Shaer (2023) assert in their research that free cash flow indicates the amount of cash a company generates available for dividends, share buybacks, debt payments, or new investments, measured by capital expenditures relative to total assets, with free cash flow defined as cash flow from operations minus capital expenditures. According to Omenihu et al. (2025), the Blau index serves as a metric to evaluate the diversity of a group or organization. Equation (4) calculated using the formula:

$$B = 1 - \sum_{i-1}^{N} p_i^2 \quad (4)$$

where, *N* represents the number of categories within the company, and p_i indicates the proportion of members in the *i*-th category.

STATA 17 was used as the analysis tool. The software processes statistical data concisely and clearly, allowing decision makers to provide a range of results accordingly.

4. RESEARCH RESULTS

Table 1 presents the descriptive statistics for the full set of variables incorporated in this investigation. This tabulation serves to characterize the sample by offering a concise summary of the data's central tendency (mean) and dispersion (standard deviation), alongside the minimum and maximum values. Methodologically, these statistics are crucial as they not only elucidate the general attributes of the firms within the sample but also establish the necessary empirical context for the robust interpretation of the subsequent econometric analyses.

Table 1. Descriptive statistics

Variable	*Obs.*	*Mean*	*Std. dev.*	*Min*	*Max*
ESG performance (*ESG*)	627	0.1579905	0.6973909	0	5.92
Carbon emissions (*CE*)	627	17.6312	2.284871	7.291731	23.75749
Profitability (*ROA*)	627	0.0385583	0.1384892	-0.9556	0.9906
Free cash flow (*FCF*)	627	7.662891	1.562005	1.30103	14.10334
Board size (*BSize*)	627	5.318658	1.974955	2	17
Board gender diversity (*BGD*)	627	0.1440803	0.1815817	0	0.5

The sample comprises 627 firm-year observations encompassing measures of sustainability performance, financial indicators, and governance attributes. ESG performance has an average value of 0.157, accompanied by a relatively high standard deviation of 0.697 and a range of 0 to 5.92, illustrating considerable variation in firms' engagement with ESG practices. Carbon emissions exhibit a mean of 17.63, with values spanning from 7.29 to 23.75, suggesting substantial differences in emission intensity, potentially driven by operational scale or reliance on carbon-intensive activities. Firm profitability, proxied by *ROA*, averages 0.038 and demonstrates wide dispersion, ranging from -0.9556 to 0.9906, indicating that the dataset includes firms with markedly poor as well as exceptionally strong financial performance. Free cash flow records a mean of 7.66, with observations ranging between 1.30 and 14.10, reflecting notable heterogeneity in financial flexibility among sampled firms. Board size averages 5.31 members, with a minimum of 2 and a maximum of 17, pointing to considerable diversity in board structures. Board gender diversity, assessed through the Blau index, has a mean of 0.144 and ranges from 0 to 0.5, indicating that although several firms achieve moderate gender-balanced representation, overall gender diversity on boards remains generally limited.

Table 2 provides the correlation matrix for the core constructs utilized in the study. This initial examination is critical for two distinct methodological purposes. First, it offers a preliminary assessment of the bivariate linear relationships among the primary variables of interest. Namely, carbon emissions, overall ESG performance, board gender diversity, and the financial control variables. Second, and equally important, the matrix allows for the early detection of multicollinearity risks among the independent variables, which is a necessary diagnostic step before proceeding with the formal multivariate regression analyses.

Table 2. Pairwise correlation

Variable	*ESG performance (ESG)*	*Carbon emissions (CE)*	*Profitability (ROA)*	*Free cash flow (FCF)*	*Board size (BSize)*	*Board gender diversity (BGD)*
ESG performance (ESG)	1.0000					
Carbon emissions (CE)	0.4152	1.0000				
Profitability (ROA)	0.1040	0.2223	1.0000			
Free cash flow (FCF)	0.1862	0.2457	0.0735	1.0000		
Board size (BSize)	0.1596	0.3636	0.0129	0.0799	1.0000	
Board gender diversity (BGD)	0.0372	0.0730	0.0559	0.0433	0.0145	1.0000

Table 2 reports the correlation coefficients among the principal variables employed in this study. ESG performance exhibits a moderate positive correlation with carbon emissions (r = 0.415), implying that firms with stronger ESG scores tend to report higher emission levels, which may reflect greater transparency or the characteristics of larger firms. ESG performance is only weakly correlated with *ROA* (r = 0.104), free cash flow (r = 0.186), and board size (r = 0.159), suggesting that sustainability performance has limited direct association with financial outcomes and governance structures. Carbon emissions show positive correlations with *ROA* (r = 0.222), free cash flow (r = 0.245), and board size (r = 0.364), indicating that firms with higher profitability, greater liquidity, or larger boards may also exhibit elevated emission levels. *ROA* demonstrates weak relationships with free cash flow (r = 0.073) and board size (r = 0.012), pointing to minimal linear dependence. Board gender diversity displays very weak correlations with all other variables (ranging from 0.014 to 0.073), suggesting that gender composition on corporate boards is largely unrelated to firms' ESG performance, emission intensity, financial metrics, or board characteristics.

Table 3 presents the summary of the multivariate regression analyses, which were conducted to rigorously test the hypothesized relationship between corporate carbon emissions and overall ESG performance, including the proposed moderating effect exerted by board gender diversity. Crucially, this table reports the estimated coefficients, the associated levels of statistical significance, and the relevant model fit statistics. These detailed results collectively constitute the fundamental empirical evidence required to evaluate the validity of the study's stated hypothesis.

Table 3. Multiple regression linear analysis: Fixed effect approach

Variable	*ESG performance*
Board gender diversity (*BGD*)	-0.030186 (0.3223)
Carbon emissions (*CE*)	0.3697653 (0.05072)***
Profitability (*ROA*)	1.091732 (0.47898)**
Free cash flow (*FCF*)	0.0784703 (0.0345)**
Board size (*BSize*)	0.1302415 (0.03217)***
Year fixed effects	Yes
Industry fixed effects	Yes
Cons	-7.2821 (0.985533)***
F-score	26.96
R^2	0.1784
N	627

*Note: ** p < 0.05, *** p < 0.01.*

Table 3 reports the regression estimates for the determinants of ESG performance. The coefficient for board gender diversity is negative and statistically insignificant (β = -0.030, p > 0.10), indicating that the gender composition of the board does not exert a meaningful influence on firms' ESG outcomes. Carbon emissions display a positive and highly significant effect on ESG performance (β = 0.369, p < 0.01), suggesting that firms with greater emission levels tend to disclose more ESG-related information or face stronger external pressures to improve sustainability reporting. Profitability, as measured by *ROA*, is positively and significantly associated with ESG performance (β = 1.091, p < 0.05), implying that financially successful firms are more capable of allocating resources toward sustainability initiatives. Free cash flow also shows a positive and significant relationship (β = 0.078, p < 0.05), reflecting that firms with stronger cash positions are better positioned to enhance their ESG activities. Board size exhibits a positive and robust association with ESG performance (β = 0.130, p < 0.01), indicating that larger boards may provide enhanced oversight and strategic guidance on sustainability issues. The model incorporates year and industry fixed effects, yielding an F-statistic of 26.96 and an R^2 of 0.1784, which indicates that approximately 17.8% of the variation in ESG performance is explained by the included predictors. The constant term is negative and statistically significant (β = -7.282, p < 0.01).

Table 4 presents the estimation outcomes derived from the time lag regression models, which serve as a crucial robustness check against methodological concerns. Specifically, the primary independent variables are incorporated wth a two-period lag to effectively mitigate potential threats arising from simultaneity bias and reverse causality in the relationship between carbon emissions and ESG performance. This temporal specification allows for the rigorous assessment of whether the hypothesized relationships maintain consistency when past values are utilized instead of contemporaneous measures. Consequently, the findings summarized in Table 4 offer heightened stability and reliability assurance regarding the primary result reported in the main regression specifications.

Table 4. Time lag regression

Variable	*Carbon emission (CE)*
Lag_ESG performance	1.217221 (0.0836399)***
Lag2_ESG performance	-0.1239444 (0.098649)
Year fixed effects	Yes
Industry fixed effects	Yes
Cons	17.3956 (0.0307049)***
F-score	439.37***
R^2	0.1482
N	627

*Note: *** p < 0.01.*

Table 4 reports the dynamic regression estimates examining the extent to which lagged ESG performance predicts subsequent carbon emissions. The results show that one-year lagged ESG Performance is positively and strongly significant (β = 1.217, SE = 0.0836, p < 0.001), indicating that firms displaying stronger ESG profiles tend to record higher carbon emissions in the following year, potentially reflecting differences in firm scale, production intensity, or disclosure practices among firms with more advanced sustainability frameworks. In contrast, the two-year lag of ESG performance yields a negative but statistically insignificant coefficient (β = -0.123, SE = 0.0986), suggesting the absence of a persistent long-term effect. Year and industry fixed effects are incorporated to account for temporal shocks and structural heterogeneity across sectors. The overall model demonstrates a strong statistical fit, with an F-statistic of 439.37 (p < 0.001) and an R^2 of 0.1482, based on a sample of 627 firm-year observations.

5. DISCUSSION

The findings of this study underscore the pivotal influence of corporate governance in determining the effectiveness of sustainability practices, with carbon emission disclosure serving as a central indicator of the environmental pillar of ESG. This correlation confirms earlier studies that corporate responses to environmental issues are improved and that more inclusive decision-making is encouraged when governance quality, especially gender diversity on boards of directors, is high (Pinheiro et al., 2023; Dike & Tuffour, 2023). Gender diversity can thereby successfully close the gap between disclosure practices and actual execution, going beyond regulatory compliance. These findings support the notion that strong governance principles must be incorporated into the decision-making process in addition to reporting for ESG effectiveness.

Effective governance frameworks that enable uniform ESG implementation and carbon disclosure requirements should be given top priority by regulators like the OJK. This is essential to lower the possibility of greenwashing, which frequently minimizes ESG to a pointless administrative formality. Companies can use gender diversity on the board of directors as a management strategy to boost legitimacy among international investors who are becoming more and more interested in transparency and to increase the credibility of sustainability reporting. Therefore, ESG's social and governance components work together to influence environmentally conscious business practices.

The discovery that carbon emissions and lagging ESG performance criteria are positively correlated underscores the intricacy of Indonesia's sustainable transformation, which is still beset by contradictions. This trend is consistent with research by Yasin (2025), which shows that initial expenditures in sustainability initiatives frequently call for high energy intensity, which could lead to a short-term increase in emissions. Because of this, ESG is a gradual process that takes longer to demonstrate its positive impacts than a reduction in carbon emissions. These results give more context by showing that a rise in ESG ratings does not always indicate a direct decrease in environmental effect; rather, it represents the beginning of a structural shift towards green business practices.

These results highlight the necessity of a thorough review of Indonesia's ESG assessment

framework, which presently prioritizes formal reporting and compliance from a regulatory standpoint. Businesses can maintain high operational emissions and high ESG scores without taking results-based measures. This puts the legitimacy of ESG policies generally at risk and opens the door for greenwashing. Thus, enhancing the quality of governance is essential to guaranteeing that ESG rankings accurately represent significant sustainability performance.

Sectoral variation also becomes increasingly apparent, with firms in energy-intensive industries exhibiting a stronger response to improvements in governance structures. This suggests that board composition may exert a more pronounced influence in sectors with inherently higher environmental exposure, highlighting the need for more differentiated regulatory approaches for high-emission industries. Such targeted oversight is essential to ensure that sustainability frameworks accurately capture the sector-specific environmental challenges faced by these firms.

The limits of using ESG as the only criterion to evaluate a company's sustainability are discussed in greater detail by these studies. ESG should be used as a starting point, and in order to make it more representative, it needs to be improved with energy transition and carbon intensity measures. While authorities must provide an assessment mechanism that encourages meaningful action rather than merely compliance, businesses must implement long-term decarbonization programs with quantifiable goals.

Lastly, the findings demonstrate that adjustments to internal company governance are just as important to the success of Indonesia's shift to a low-carbon economy as macroregulations like POJK.03/2017 and POJK No. 17 of 2023. ESG implementation in Indonesia can be improved, global standards compliance can be guaranteed, and businesses' competitiveness in the global market can be increased by coordinating external legislation with internal governance. The key to building a business ecosystem with integrity and worldwide competitiveness is the cooperation of public policy, corporate openness, and a sustained dedication to sustainability. However, the study faces data constraints due to its sole use of Bloomberg as the source, which, despite its broad coverage, may not encompass the full range of variation available in other global databases.

6. CONCLUSION

This study provides strong empirical evidence that corporate governance mechanisms, particularly board gender diversity, play a pivotal role in enhancing environmental transparency and supporting firms' broader sustainability transitions. Strengthened governance practices are shown to improve the credibility of carbon emissions disclosures and reinforce the alignment between environmental reporting and strategic organizational actions. From a theoretical standpoint, these findings extend RDT, which posits that board members function as channels of critical resources shaping firms' strategic adaptability. The results suggest that female directors contribute informational, relational, and legitimacy-based resources that enhance corporate responsiveness to environmental pressures and foster more inclusive, accountable decision-making processes. Accordingly, gender diverse boards serve as an internal governance mechanism that mitigates inconsistencies between stated ESG commitments and actual environmental performance, particularly in regulatory contexts where enforcement remains uneven.

Furthermore, the analysis demonstrates that Indonesia's transition toward a low-carbon economy relies not only on overarching regulatory frameworks such as POJK.03/2017 and POJK No. 17 of 2023 but also on the strength of firm-level governance. Effective integration of external mandates with robust internal governance structures is essential for achieving credible ESG implementation, strengthening alignment with global sustainability standards, and enhancing the international competitiveness of Indonesian firms. Sector-specific insights reveal that companies in energy-intensive industries respond more strongly to governance improvements, underscoring the need for differentiated regulatory approaches that better account for varying levels of environmental exposure.

Overall, the study reinforces that ESG should be viewed not merely as a compliance obligation but as a comprehensive strategic framework requiring transparency, governance integrity, and long-term commitment. However, the generalizability of the findings is limited by the focus on publicly listed Indonesian firms and the study's exclusive reliance on Bloomberg as the sole data source, which, despite its extensive coverage, may not capture the full variability available in other international repositories. The use of primarily quantitative indicators may also overlook qualitative dimensions of sustainability practice, potentially resulting in measurement bias.

Future research should address these limitations by incorporating qualitative assessments such as boardroom dynamics, stakeholder engagement insights, or case analyses to capture the nuanced mechanisms through which gender diversity influences environmental governance. Expanding the analysis to cross-national samples or longer time horizons would also strengthen the robustness of conclusions and deepen understanding of how regulatory frameworks, cultural contexts, and energy transitions shape the ESG emissions relationship. Advancing these research pathways will contribute to more substantive academic discourse and more effective strategies for promoting sustainable corporate behavior.

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