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An Analysis of Gender Diversity in Top Management and Its Impact on Carbon Emission Disclosure

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Abstract

Purpose: This study examines the impact of top management gender diversity on carbon emissions disclosure in IDX-listed companies from 2019 to 2023.

Research Methodology: This quantitative study utilizes purposive sampling and panel data regression to analyze secondary data from the annual and sustainability reports of IDX-listed companies in the energy, basic materials, and primary consumer sectors (2019–2023), investigating the impact of top management gender diversity on carbon emission disclosure while controlling for firm size, sustainability committees, profitability, and managerial ownership.

Results: All variables, including gender diversity, significantly impact carbon emissions disclosure when considered together. The sustainability committee shows a significant positive effect, while profitability has a significant negative effect; in contrast, gender diversity, firm size, and managerial ownership have no significant impact.

Conclusions: This study concludes that while all variables simultaneously affect carbon disclosure, only the sustainability committee and profitability significantly enhance transparency, whereas gender diversity has no impact. This proves that formal governance structures are more effective in driving environmental disclosures than management demographics. These findings serve as a strategic recommendation for regulators and companies to strengthen sustainability reporting standards in Indonesia.

Limitations: This study is limited to three industrial sectors, lacks qualitative depth, and has a five-year observation period that may not reflect long-term trends.

Contributions: This study enriches the environmental accounting literature on emerging markets and offers policy implications for regulators regarding carbon reporting standardization and incentive schemes to accelerate national ESG adoption.

Keywords: *Carbon Emission Disclosure, Environmental Disclosure, Firm Size, Gender Diversity, Managerial Ownership*

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1. Introduction

Currently, climate change represents the greatest challenge to humanity, driven by industrialization, fossil fuel consumption, and deforestation. This phenomenon not only threatens ecosystems but also impacts global health and economic stability (Nguyen, Yang, Nguyen, & Nguyen, 2023). To demonstrate its responsibility, the Indonesian Government has strengthened its commitment to achieving net-zero emissions by 2060 through Government Regulation (PP) No. 40 of 2025 regarding the National Energy Policy. Despite continuous regulatory updates, data reveal significant challenges

on the ground. Indonesia's Greenhouse Gas (GHG) emissions increased by 10% in 2022, totaling 1.24 gigatons of carbon dioxide (Crippa et al., 2024).

This study focuses on the primary issues of transparency gaps and inconsistencies in carbon emissions disclosures among entities in the energy, basic materials, and primary consumer sectors. Although regulations such as Financial Services Authority Regulation *No. 51/POJK.03/2017* require sustainability reports, carbon emission disclosure in Indonesia remains voluntary and non-standardized to date (Manurung, Setiany, Saputra, & Hapsari, 2022). Environmental pollution cases involving several industries, such as those involving PT Semen Gresik and Toba Pulp Lestari, further emphasize that not all companies share the same commitment to reporting their environmental impacts. Environmental pollution cases involving several industries such as those involving PT Semen Gresik and Toba Pulp Lestari further emphasize that not all companies share the same commitment to reporting their environmental impacts.

This study evaluated whether internal governance aspects, specifically the role of women on the board of directors, can serve as a solution to enhance transparency. Theoretically, the presence of women in executive positions is believed to bring a perspective that is more sensitive to ethical and moral values than male leadership styles, which tend to be more competitive (L. Liao, Luo, & Tang, 2015). Although many developed countries and neighboring nations, such as Malaysia, have established gender quotas for boards of directors, Indonesia currently lacks explicit regulations mandating female representation.

This study aims to examine whether gender diversity in top management has a positive impact on the quality of carbon emission disclosures as a step toward maintaining corporate legitimacy in the eyes of the public. The objective of this research is to provide a comprehensive understanding of the factors influencing transparency in carbon emission disclosures among companies listed on the Indonesian Stock Exchange (IDX) during 2019–2023, considering control variables such as company size, sustainability committees, profitability, and managerial ownership.

2. Literature review and hypothesis/es development

2.1. Gender Diversity and Carbon Emission Disclosure

The implementation of robust GCG principles serves as a protective mechanism for stakeholder rights while simultaneously ensuring the fulfillment of corporate social responsibility. A transparent management structure encourages companies to voluntarily share information regarding environmental issues and CSR with the public (Khan, Muttakin, & Siddiqui, 2013). Furthermore, diversity within the board in terms of gender, background, and expertise is considered capable of enhancing the quality of corporate oversight and accountability (Al-Qahtani & Elgharbawy, 2020).

Drawing from stakeholder theory, the board of directors' functions not only as a corporate governance mechanism but also as a representative body that balances the conflicting demands of various interest groups to maintain social legitimacy. In this context, gender diversity is crucial because female directors are often associated with a stronger orientation towards Corporate Social Responsibility (CSR) and ethical behavior. Consequently, a gender-diverse board is more likely to prioritize the transparency of environmental impacts, such as carbon emissions disclosure, to satisfy the information needs of environmentally conscious stakeholders.

Furthermore, resource dependency theory posits that boards provide critical resources, such as expertise and legitimacy, to manage external dependencies. Gender diversity enriches the board's human capital by introducing unique perspectives and problem-solving skills that enhance the board's ability to assess environmental risks. This strategic capability drives companies to adopt more comprehensive carbon disclosure practices to secure external support and resources. Recognizing these benefits, developed nations, such as Australia, the United Kingdom, and the United States, have increasingly mandated or encouraged female representation to strengthen corporate governance frameworks (Ben-Amar, Chang, & McIlkenny, 2017).

The involvement of women on the board of directors is closely associated with specific leadership styles and ethical orientations. Female leaders are often perceived to excel in communication, setting priorities, and focusing on processes rather than merely the end results (Houqe, Opare, & Zahir-Ul-Hassan, 2024). This ethical orientation makes women more sensitive to the disclosure of non-financial information, including carbon emission transparency (Ben-Amar et al., 2017). This study is supported by extensive empirical evidence from various contexts. For instance, Ben-Amar et al. (2017) indicate that women involved in the board of directors have the capacity to enhance voluntary transparency regarding carbon emissions. This finding is consistent with that of L. Liao et al. (2015), who found that the presence of at least two female directors in FTSE 350 companies facilitated climate change strategies and improved Carbon Disclosure Project (CDP) scores.

Nevertheless, the existence of inconsistent findings presents a notable research gap. Prado-Lorenzo and Garcia-Sanchez (2010) and Fadhlihi and Fatriansyah (2023) suggest that gender diversity does not significantly impact carbon emissions disclosure. These discrepancies can be attributed to contextual differences, particularly regulatory environments and industrial characteristics. In highly regulated jurisdictions, the marginal effect of board diversity may be diminished as compliance becomes mandatory rather than voluntary. Furthermore, differences in research methodologies, such as the measurement of disclosure indices versus binary adoption, may also contribute to these conflicting results. Despite these debates, the prevailing literature supports the assumption that the presence of women in top management reinforces corporate dedication to environmental issues. Based on this rationale, we propose the following hypothesis:

H_1: Gender diversity on the board of directors positively affects carbon emission disclosure.

Beyond the internal governance structure represented by board diversity, organizational characteristics, such as the scale of operations and resource availability, also play a pivotal role in determining disclosure levels, leading to the consideration of firm size.

2.2. Company Size and Carbon Emission Disclosure

Companies report and implement their social responsibility and environmental impacts based on their size. Given that carbon emission disclosure requires significant financial and technical resources, large-scale companies are considered more capable of bearing the costs of pollution mitigation than smaller firms (Freedman & Jaggi, 2005). This view is supported by Kalu, Buang, Aliagha, and Malaysia (2016), who state that large company size provides an advantage in funding emission reduction programs while simultaneously managing information, from the data collection stage to the reporting phase.

From the perspective of legitimacy theory, large-scale companies operate under intensified social and political visibility, subjecting them to stricter public and media scrutiny. To maintain their 'social contract' and legitimacy, these entities utilize carbon emission disclosure not merely as a compliance measure, but as a strategic mechanism to manage public pressure and construct a positive corporate image (Nasih, Harymawan, Paramitasari, & Handayani, 2019). Furthermore, consistent with stakeholder theory, larger firms face greater demands from a diverse group of stakeholders, including regulators and environmental investors, necessitating more transparent reporting. Firm size, typically measured by total assets, serves as a proxy for resource availability and operational capacity (Hermawan, Aisyah, Gunardi, & Putri, 2018). Supported by substantial assets, large companies possess the necessary 'financial slack' to fund sophisticated environmental accounting systems, obtain costly carbon certifications, and improve data quality. Consequently, larger firms are better positioned and more motivated to disclose carbon emissions to satisfy stakeholder expectations compared to their smaller counterparts.

Various empirical findings consistently demonstrate a positive correlation between company size and the depth of environmental information transparency. Aguilar-Fernández and Otegi-Olaso (2018) revealed that large-scale organizations tend to document more environmental indicators and exhibit superior innovative attitudes toward sustainability efforts. In the context of emerging markets, Akbaş and Canikli (2018) found a positive impact of firm size on voluntary participation in carbon emission reporting in Turkey. Similar findings were reported in Indonesia and Malaysia, where company size

significantly influences investor responses and the transparency level of carbon reports (Safelia & Muda, 2023).

These consistent results can be attributed to the fact that larger firms operate under higher public visibility and stricter regulatory pressure, compelling them to disclose more information to maintain legitimacy. Additionally, large entities possess greater financial and human resources, enabling them to absorb the costs associated with complex carbon reporting, a capability often lacking in smaller firms. In this study, company size is established as a control variable to minimize the risk of omitted variable bias and to ensure that the estimation of the impact of board gender diversity is not confounded by differences in organizational scale. Based on this theoretical and empirical framework, we propose the following hypothesis:

H_2: Company size has a positive effect on carbon emissions disclosure.

While company size determines the resource capacity for reporting, the actual oversight mechanism to ensure the quality of such disclosures relies on specific governance structures. This necessitates an examination of the Sustainability Committee.

2.3. Sustainability Committee and Carbon Emission Disclosure

In the current environmental accounting literature, the link between the existence of a sustainability committee and the quality of carbon emission transparency has become a central topic. An international study by Driss, Drobetz, El Ghoul, and Guedhami (2024) demonstrates that organizations that establish a sustainability committee tend to disclose carbon emission data more comprehensively, often supported by more credible external verification processes. These findings emphasize that the formation of such a committee is not merely a symbolic act for regulatory compliance but carries a tangible economic impact by substantially improving corporate environmental transparency.

Several studies report a positive correlation between the existence of an environmental committee and an overall increase in corporate environmental performance (Dixon-Fowler, Ellstrand, & Johnson, 2017). However, some researchers caution that these committees sometimes function only as symbolic mechanisms to gain social legitimacy without actual performance improvements, a practice commonly known as greenwashing (Berrone & Gomez-Mejia, 2009). These conflicting findings can be largely attributed to variations in regulatory environments and industrial contexts. In jurisdictions with weak institutional enforcement, committees may serve merely as 'window dressing' to secure legitimacy. Conversely, in countries with strict environmental regulations or within high-impact industries (such as energy or mining), these committees are compelled to function as substantive oversight bodies rather than symbolic ones (Driss et al., 2024).

Furthermore, differences in research methodologies, such as measuring the mere presence of a committee versus assessing its expertise and activity frequency, may also contribute to these empirical discrepancies. Despite these variations, this study utilizes the sustainability committee as a control variable to minimize the risk of omitted variable bias. The presence of a committee at the board level can moderate the influence of other internal factors on the quality of emission disclosures (Ali, Wilson, & Frynas, 2024). Additionally, evidence suggests that ESG-based governance mechanisms significantly influence disclosure output, particularly in extractive industries (Mshana, 2024). By controlling for this variable, this study aims to isolate the pure influence of gender diversity on carbon emission disclosures, thereby producing more accurate coefficient estimates.

H_3: The sustainability committee positively affects carbon emissions disclosure.

Although governance structures provide the necessary oversight for environmental reporting, the implementation of such comprehensive disclosure systems requires substantial financial resources. Consequently, a company's ability to bear these costs is closely linked to its economic performance, necessitating an examination of its profitability.

2.4. Profitability and Carbon Emission Disclosure

Drawing directly from legitimacy theory, companies achieving high profitability typically operate under intensified public visibility and scrutiny. Society often questions whether superior financial returns are achieved at the expense of environmental degradation. Consequently, these firms utilize carbon emission disclosure as a strategic tool to legitimize their operations, proving to the public that their profit generation aligns with societal values and environmental (Wahyuningrum, Ihlashul'amal, Utami, Djajadikerta, & Sriningsih, 2024). From the perspectives of agency and signaling theory, the decision to engage in voluntary disclosure is fundamentally a cost-benefit function aimed at reducing information asymmetry between management and shareholders.

Managers of profitable firms are incentivized to disclose carbon emissions to demonstrate their effective management of long-term environmental risks and to justify their compensation. A strong financial position is a prerequisite for this strategy, as it enables companies to fund the complex process of identifying, compiling, and verifying carbon data. Because these reporting activities involve high proprietary and preparation costs, signaling theory suggests that only profitable firms can afford to send this credible signal of quality to the market. Consequently, profitability is predicted to facilitate superior transparency, providing long-term legitimacy benefits and distinguishing the company from less capable competitors (Saraswati, Puspita, & Sagitaputri, 2021).

Empirical findings in Indonesia consistently support these arguments. A study on the non-financial sector for the 2017–2021 period demonstrates that profitability statistically influences carbon emission transparency, which is directly related to a company's financial capacity to fund reporting costs (Wahyuningrum et al., 2024). Furthermore, Henriawan, Mukhibad, Pertiwi, and Himmatina (2024) show that businesses with high profit levels exhibit greater flexibility in responding to legitimacy pressures through Carbon Emission Disclosures (CEDs) (Sierra-Díaz, Gonzalez-Villora, Pastor-Vicedo, & López-Sánchez).

In this research model, profitability is established as a control variable to mitigate the risk of omitted variable bias. Although several previous studies have recorded mixed results, controlling for this variable is essential to isolate the effects of financial performance from the primary influence being studied, namely board gender diversity (Velte, Stawinoga, & Lueg, 2020). Profitability in this study is operationalized through the Return on Assets (ROA) ratio, calculated by dividing net income by total assets, in accordance with standard practices in international carbon disclosure research (Desai, 2022).

H_4: Profitability positively affects carbon emissions disclosure.

2.5. Managerial Ownership and Carbon Emission Disclosure

Managerial ownership is a crucial governance mechanism for mitigating agency problems. Based on agency theory, share ownership by managers and directors is believed to positively contribute to the level of voluntary disclosure through the convergence-of-interest concept. In this condition, managers who are also shareholders align their personal goals with the interests of other shareholders. Specifically, regarding transparency efforts, managers with equity stakes are motivated to reduce information asymmetry to increase firm value. By disclosing carbon emissions, managers signal superior environmental risk management and legitimacy to the market, which can enhance stock liquidity and valuation, thereby directly benefiting their personal wealth (Jensen & Meckling, 2019). Consequently, high managerial ownership encourages strategic decisions oriented toward long-term sustainability and detailed reporting to preserve the firm's future value (Toukabri & Mohamed Youssef, 2023).

However, the literature also recognizes an alternative effect known as managerial entrenchment. This effect arises when managers control a large amount of equity, granting them sufficient voting power to influence corporate decisions for personal gain (Shan, Tang, & Zhang, 2021). In the context of carbon emissions disclosure, this entrenchment can lead to opacity. Entrenched managers may perceive detailed environmental reporting as a risk that invites regulatory scrutiny or public criticism, particularly if the firm's environmental performance is poor. To avoid external monitoring and protect their positions from the reputational damage associated with high emissions, entrenched managers may

choose to suppress carbon information, prioritizing their job security over the informational needs of stakeholders (Shan et al., 2021).

Empirical findings regarding the impact of managerial ownership on carbon emission transparency have shown inconsistent results. In Indonesia, this phenomenon is reflected in diverse research data. Akhiroh and Kiswanto (2016) found a significant positive influence, in which share ownership encourages management to maintain their reputation through the transparency of environmental information. Conversely, Singhania and Bhan (2025) indicated no significant effect, presumably because the low average percentage of managerial ownership is insufficient to create a strong alignment of interests that attracts investor attention.

In this study, managerial ownership is established as a control variable. This step is taken because variations in ownership structure have been proven to systematically influence the strategy and intensity of voluntary carbon emission disclosures (Sierra-Díaz et al.). Without controlling for this variable, there is a risk of omitted variable bias, in which the influence of the main variable (such as board gender diversity) might be confounded by variations in managerial behavior originating from their shareholding proportions (C.-H. Liao, San, & Tsang, 2024).

H_5: Managerial ownership positively affects carbon emissions disclosure.

As discussed above, Figure 1 presents the conceptual framework illustrating the relationships between the variables in this study.

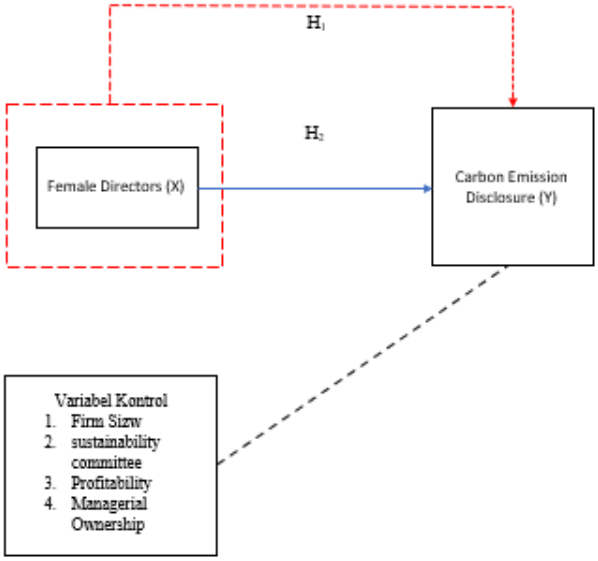

Figure 1. Research framework

3. Methodology

This study employs a quantitative analysis method with a descriptive statistical approach. The selected analytical technique is panel data regression, as the research subjects include multiple companies (cross-section) observed over several years (time series). Data processing was optimized using EViews 13 software to ensure the accuracy of the model selection process. EViews was specifically selected over general statistical packages (e.g., SPSS) because of its specialized architecture for econometric analysis and time-series forecasting. This software offers superior precision in handling panel data structures and provides comprehensive diagnostic tools, thereby enhancing the robustness of the regression results compared to general-purpose tools. According to Ghozi and Hermansyah (2018), panel data regression integrates cross-sectional and time-series data. The application of panel data provides several advantages, notably increasing the degrees of freedom, which helps minimize the risk of estimation bias in large datasets (Savitri et al., 2021). In this model, the degrees of freedom serve as an indicator of model robustness, representing the extent to which the values of independent variables can fluctuate without exceeding established constraints.

3.1. Research Model

The research framework integrates three categories of variables: dependent, independent, and control. Carbon emission disclosure is positioned as the dependent variable, whereas gender diversity serves as the primary independent variable. To ensure the accuracy of the results, this study includes company size, sustainability committee, profitability, and managerial ownership as control variables. By adopting a quantitative approach, this research utilizes empirical data to analyze the interrelationships and influences between these variables in depth.

3.1.1. Classical Assumption Tests

To ensure that the resulting estimates are unbiased, this study utilizes classical assumption tests to verify that the regression model meets the Best Linear Unbiased Estimate (BLUE) criteria (Gujarati, 2009). Three types of classical assumption tests were employed in this panel data regression analysis.

3.1.1.1. Normality Test

The normality test was used to determine whether the data distribution in the study was normal. Data were categorized as normally distributed if the majority of standardized residual values clustered around their mean (Zahriyah, Suprianik, Parmono, & Mustofa, 2022). This is typically indicated by a bell-shaped curve. Technically, this test was performed by assessing the Jarque–Bera (JB) probability value against a 5% significance level. The JB probability value was considered normal if it was greater than 5% ($P > 0.05$); conversely, if the value was less than 5%, the data distribution was considered non-normal. If the normality assumption was violated, this study applied data transformation techniques (such as the natural logarithm or square root) or removed significant outliers to achieve a normal distribution.

3.1.1.2. Multicollinearity Test

The multicollinearity test was conducted to determine whether there was a correlation between the independent variables in the regression model. The Variance Inflation Factor (VIF) was utilized for this detection process. Based on the decision-making criteria, if the VIF value was less than 10 ($VIF < 10$), the model was free from multicollinearity; however, if the VIF value exceeded 10, it could be concluded that the model suffered from multicollinearity issues. If multicollinearity occurred, remedial actions were taken, such as removing one of the highly correlated variables from the model or increasing the sample size to reduce standard errors.

3.1.1.3. Heteroscedasticity Test

The heteroscedasticity test was employed to determine whether the variance of the residuals in a regression model remained constant across all observation points. The Glejser test is a commonly used tool to identify this condition. The decision-making guideline states that if the probability value (p-value) is greater than 0.05, the model is free from heteroscedasticity; conversely, if the probability value is less than 0.05, the model is considered to have a heteroscedasticity problem. In the event of heteroscedasticity, this study will employ robust standard errors (or heteroscedasticity-consistent standard errors) to correct the standard errors and ensure valid hypothesis testing.

3.1.2. Panel Data Regression Model Selection

Brooks (2014) states that panel data regression analysis relies on three primary estimation approaches: the Common Effects Model (CEM), Fixed Effects Model (FEM), and Random Effects Model (REM). To ensure the robustness of the empirical results, a specific series of diagnostic tests is required to identify the most appropriate specification for the data structure.

First, the Chow test was conducted to compare the fixed effects model with the common effects model; this test is essential to determine whether significant individual heterogeneity exists across cross-sections, which would render a simple pooled regression biased. Subsequently, the Hausman test was employed to discriminate between the fixed effects and random effects models by assessing whether the unique errors are correlated with the regressors, thereby identifying a consistent estimator. Finally, the Lagrange Multiplier (LM) test was utilized to ascertain the presence of random effects variances and to determine whether the random effects model is more appropriate than the common effects model.

3.1.3. Hypothesis Testing

Sugiyono (2013) defines a hypothesis as an initial assumption proposed as a preliminary answer to the research problem formulation. However, these assumptions are not arbitrary; they are directly synthesized from the theoretical frameworks and empirical inconsistencies discussed in the literature review. Consequently, the hypotheses in this study serve as a bridge to test whether the theoretical expectations derived from legitimacy and stakeholder theories align with empirical reality.

The execution of hypothesis testing aims to verify the presence or absence of a relationship between independent and dependent variables. If a hypothesis successfully passes the testing phase, it not only validates the proposed model but also has the potential to transform into a new scientific theory within the respective field of research (Balaka, 2022).

3.1.3.1. Model Feasibility Test (R^2)

The extent to which the independent variables explain the variation in the dependent variable within a model is assessed using the coefficient of determination (R^2) test (Ghazali, 2011). (Ghazali, 2011)states that a smaller R^2 value indicates that the influence of the independent variables on the dependent variable is very limited. Conversely, a higher R^2 value signifies that the independent variables provide nearly all the information required to accurately predict the behavior of the dependent variable.

3.1.3.2. Simultaneous Testing (F-Test)

As proposed by Tahir et al. (2023), the F-statistic test is used to determine whether the dependent variable and all independent variables collectively influence one another. The simultaneous testing criteria for this study are as follows: a probability value ($p \geq 0.05$) indicates that gender diversity, along with the control variables including firm size, sustainability committee, profitability, and managerial ownership, does not significantly affect carbon emission disclosure. Conversely, a probability value ($p \leq 0.05$) indicates that these variables simultaneously influence carbon emission transparency.

3.1.3.3. Partial Testing (t-Test)

The t-test was utilized to assess the significance of the partial effect of each independent variable on the dependent variable, in accordance with (Ghozi & Hermansyah, 2018). In this study, the hypothesis testing criteria were as follows: a probability value (p-value) ≤ 0.05 indicates that gender diversity has a significant effect on carbon emission disclosure. On the other hand, if the p-value is ≥ 0.05, gender diversity does not have a significant impact on carbon emission transparency.

3.2. Research Population and Sample

Sugiyono (2013) states that a population is a general group consisting of objects or subjects with specific characteristics and qualities determined by the researcher to be analyzed and understood before drawing conclusions. Beyond individuals, a population encompasses objects and natural entities. For the 2019–2023 period, this study focuses on companies listed on the Indonesian Stock Exchange (IDX) operating in the energy, basic materials, and consumer staples sectors.

According to Sugiyono (2013), a sample is a representation of a small portion of the population's characteristics. Sampling is utilized to overcome the researcher's time and energy constraints in reaching the entire population, based on the assumption that the results of the sample analysis can be applied to the population.

In this specific context, purposive sampling is more suitable than random sampling. While random sampling ensures equal probability, it poses a risk of selecting companies that do not disclose environmental data, resulting in incomplete datasets. Purposive sampling is necessary to ensure that the selected firms possess the required attributes, such as the availability of carbon emission data in high-impact sectors, which are critical for testing the research hypotheses.

Consequently, this study applies the following criteria: (1) companies in the energy, basic materials, and consumer staple sectors listed on the IDX from 2019 to 2023; (2) consistently listed throughout the observation period; (3) regularly publish annual reports; and (4) regularly publish sustainability reports.

Based on these criteria, 131 companies were selected as the sample, resulting in a total of 655 observations over the five-year research period

3.3. Operational Definition of Variables

Operational variables are defined as specific attributes or values intentionally established by the researcher to be investigated to obtain accurate data as the foundation for drawing conclusions. Within this research framework, these variables are classified into two primary categories: independent and dependent variables (Table 1).

Table 1. Operational definition of variables

Variables	Definition	Measurement
GD	Proportion of women on the board of directors (Nadifah, Dahlan, & Handoyo, 2025).	$\frac{Number\ of\ Women\ on\ The\ Board\ of\ Directors}{Total\ Number\ of\ Board\ Members}$
UP	Firm size is an indicator that classifies the scale of a business based on specific parameters such as total assets, sales volume, and market capitalization (Christiane, Indrabudiman, & Handayani, 2022).	In (*Total Aset*)
SC	A sustainability committee serves as an extension of the corporate governance function, overseeing the business's impact on various stakeholders, including communities, employees, customers, suppliers, and the environment (Driss et al., 2024)	1 = Whether the company has a sustainability committee or specialized sustainability/CSR unit at the board level. 0 = If the company does not have a sustainability committee.
P	Profitability reflects a firm's ability to generate profit, which can be measured using the Return on Assets (ROA) ratio as a proxy (Ridhwan & Dwiati, 2022).	$\frac{Net\ Income}{Net\ Profit}\ x\ 100\ \%$
KM	Managerial ownership refers to the proportion of shares held by management members who play an active role in the company's strategic decision-making process (Galingging & Yulianto, 2024).	$\frac{Managerial\ Share\ Ownership}{Total\ Share\ Outstanding}$
CED	Carbon emission disclosure is defined as corporate transparency in communicating various dimensions of carbon management. This encompasses reporting on long-term strategies, environmental initiatives, the implementation of sustainable practices, and a company's performance outcomes in mitigating its generated emissions. To empirically measure this variable, this study employs a disclosure index adopted, which is widely recognized in the environmental accounting literature. The index comprises 18 specific items derived from the Carbon Disclosure Project (CDP) questionnaire, categorizing disclosures into five key themes: climate change risks and opportunities (CC), Greenhouse Gas	$CED = \frac{Total\ Number\ of\ Item\ Used}{18}$

	Emissions (GHG), Energy Consumption (EC), greenhouse gas Reduction and Cost (RC), and Carbon Emission Accountability (AEC). Consequently, the Carbon Emission Disclosure (Sierra-Díaz et al.) score is calculated using the ratio of the total number of items disclosed by the company to the maximum score of 18, as shown in the following formula	

4. Results and Discussions

4.1. Result

4.1.1. Classical Assumption Tests

4.1.1.1. Multicollinearity Test

	X	K1	K2	K3	K4
X	1.000000	-0.032864	-0.004420	0.032288	-0.083429
K1	-0.032864	1.000000	0.055393	0.005476	-0.043518
K2	-0.004420	0.055393	1.000000	0.043773	-0.065589
K3	0.032288	0.005476	0.043773	1.000000	0.014524
K4	-0.083429	-0.043518	-0.065589	0.014524	1.000000

Figure 2. Multicollinearity test

Figure 2 shows gender diversity (*X*), company size (K1), sustainability committee (K2), profitability (K3), and managerial ownership (K4) served as the independent and control variables. The test was conducted using a correlation matrix to identify potential multicollinearity between these variables. The results indicate that the overall inter-variable correlation coefficients are low. The correlation between gender diversity (*X*) and managerial ownership (K4) represents the highest value at -0.083429, which is significantly below the 0.80 threshold. Given that no coefficient exceeds this limit, it can be concluded that the regression model is free from multicollinearity issues and is suitable for further analysis.

4.1.1.2. Heteroscedasticity Test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.154776	0.009935	15.57938	0.0000
K1	5.13E-18	3.96E-17	0.129611	0.8969
K2	-0.017411	0.016593	-1.049316	0.2945
K3	0.052666	0.020960	2.512760	0.3123
K4	0.336663	0.214781	1.567467	0.1176
X	-0.030787	0.049736	-0.619004	0.5362

Figure 3. Heteroscedasticity test

Figure 3 shows according to the results of the Glejser test, the probability values obtained from regressing the independent variables against the absolute residuals indicate the significance of each variable. The results show probability values for gender diversity (0.5362), company size (0.8969), sustainability committee (0.2945), profitability (0.3123), and managerial ownership (0.1176). The model shows no signs of heteroscedasticity, as all probability values exceed the 0.05 threshold. This ensures that the regression model has homoscedastic or constant residual variance. Consequently, the model is suitable for further analysis.

4.1.2. Selection of Regression Model

The most appropriate estimation model was selected from the Common Effect Model (CEM), Fixed-Effect Model (FEM), and Random-Effect Model (REM) through a series of selection stages. Determining the best model required the following statistical tests:

4.1.2.1. Chow Test

Redundant Fixed Effects Tests Equation: Untitled Test cross-section fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	13.968681	(130,519)	0.0000
Cross-section Chi-square	985.010394	130	0.0000

Figure 4. Chow test

Figure 4 shows the cross-section chi-square probability value of 0.0000 is lower than the 0.05 significance level, as shown by the Chow test results in Table 4. These results indicate that the Fixed-Effects Model (FEM) is more appropriate than the Common-Effects Model (CEM) for the panel data regression model selection.

4.1.2.2. Hausman test

Correlated Random Effects - Hausman Test Equation: Untitled Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	25.890510	5	0.0001

Figure 5. Hausman test

As shown in Figure 5, the chi-square statistic for the cross-section random effect is 25.890510 with a probability level of 0.0001. The null hypothesis is rejected because the p-value is less than 0.05. Therefore, it can be concluded that the Fixed-Effects Model (FEM) is more appropriate for this study than the Random-Effects Model (REM).

4.1.2.3. Lagrange Multiplier Test

Lagrange Multiplier Tests for Random Effects Null hypotheses: No effects Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives			
	Test Hypothesis Cross-section	Time	Both
Breusch-Pagan	607.4283 (0.0000)	53.47257 (0.0000)	660.9008 (0.0000)

Table 6. Lagrange multiplier test

Figure 6 shows the cross-section statistic value was 607.4283 with a probability level of 0.000, according to the Lagrange Multiplier (Breusch-Pagan) test results. Consequently, the null hypothesis (H_0) is rejected. This indicates that the random effects model was more appropriate for this study than the common effects model.

4.1.2.4. Model Selection Conclusion

After undergoing a series of model selection procedures, including the Chow, Hausman, and Lagrange multiplier tests, it can be concluded that the most accurate and appropriate estimation method to be applied in this study is

Table 2. Model selection conclusion

Metode	Hasil
Chow Test	*Fixed Effect Model*
Hausman Test	*Fixed Effect Model*
Langrange Multiplier Test	*Random Effect Model*

Table 2 shows the hierarchy of econometric testing, the Fixed-Effects Model (FEM) was determined to be the most accurate and appropriate estimation method for this study. Although the Lagrange multiplier test suggested that the random-effects model was better than the common-effects model, the decisive Hausman test confirmed that the fixed-effects model was statistically superior to the random-effects model.

The selection of the fixed effects model offers a distinct advantage in this specific research context. FEM is particularly robust in controlling for unobserved individual heterogeneity—unique characteristics of each company (such as corporate culture or managerial style)–that remain constant over time but are not explicitly measured in the model. By accounting for these time-invariant factors, FEM reduces the risk of omitted variable bias, thereby providing a more consistent and valid estimate of how independent variables influence carbon emissions disclosure.

4.1.3. Hypothesis Testing

One of the primary objectives of hypothesis testing is to determine the significance of the impact of independent variables on the dependent variable. The two main methods in this analytical process are the t-test, which is used to evaluate partial or individual effects, and the F-test, which is used to assess the simultaneous or collective strength of those effects.

4.1.3.1. F-Test (Simultaneous Significance Test)

R-squared	0.797251	Mean dependent var	0.490161
Adjusted R-squared	0.744513	S.D. dependent var	0.209312
S.E. of regression	0.105798	Akaike info criterion	-1.472033
Sum squared resid	5.809290	Schwarz criterion	-0.540872
Log likelihood	618.0907	Hannan-Quinn criter.	-1.110985
F-statistic	15.11717	Durbin-Watson stat	1.237413
Prob(F-statistic)	0.000000		

Figure 7. Results of Simultaneous Significance Test (F-Test)

Figure 7 shows on the F-test results, the regression model was considered statistically significant. The F-statistic value was 15.11717 with a significance level (Prob F-statistic) of 0.000000, which is well below the 0.05 threshold. In this context, the gender diversity variable was examined to evaluate the influence of gender diversity within the organizational structure on environmental transparency through carbon emissions disclosure.

4.1.3.2. Coefficient of Determination (R^2)

R-squared	0.797251	Mean dependent var	0.490161
Adjusted R-squared	0.744513	S.D. dependent var	0.209312
S.E. of regression	0.105798	Akaike info criterion	-1.472033
Sum squared resid	5.809290	Schwarz criterion	-0.540872
Log likelihood	618.0907	Hannan-Quinn criter.	-1.110985
F-statistic	15.11717	Durbin-Watson stat	1.237413
Prob(F-statistic)	0.000000		

Figure 8. Results of the Coefficient of Determination Test (R^2)

Figure 8 shows on the results of the coefficient of determination test shown in the table above, the R-squared value of 0.797251 indicates that the independent and control variables in this model account for 79.73% of the variation in carbon emissions disclosure. The adjusted R-squared value is 0.744513, indicating that the explanatory power of the model, after adjusting for the number of variables used, is 74.45%. The difference between these two values reflects the model's adjustment for the degrees of freedom; nevertheless, these figures demonstrate the model's capability to predict the dependent variable.

The relatively small margin between the R-squared and Adjusted R-squared values suggests that the model is robust and free from overfitting. This implies that the inclusion of specific independent and control variables in this study genuinely contributes to the explanatory power of the model, rather than merely inflating the statistics due to the addition of variables. Furthermore, an explanatory power exceeding 70% is considered substantial in social science research, indicating that the selected model effectively captures the primary drivers of carbon emission disclosure behavior among the sampled companies

4.1.3.3. Partial Significance Test (t-Test)

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.496915	0.011973	41.50158	0.0000
X	0.017141	0.059943	0.285952	0.7750
K1	-7.92E-18	4.77E-17	-0.165868	0.8683
K2	0.063607	0.019998	3.180685	0.0016
K3	-0.051364	0.025261	-2.033345	0.0425
K4	-0.379418	0.258858	-1.465738	0.1433

Figure 9. Partial Significance Test Results (t-Test)

Based on the partial test (t-test) results presented in Figure 9, the findings for each independent variable are as follows:

a. Gender diversity (X) has no significant effect on carbon emissions disclosure, as indicated by a t-statistic of 0.285952, which is lower than the t-table value (1.96), and a p-value of 0.7750, which exceeds 0.05. This implies that changes in gender diversity do not impact a company's carbon emissions disclosure.
b. Company Size (K1) does not significantly influence carbon emission disclosure, as evidenced by a t-statistic of -0.165868, which is lower in absolute terms than the t-table value (1.96) and a p-value of 0.8683, which is greater than 0.05.
c. The Sustainability Committee (K2) has a significant effect on carbon emission disclosure, with a t-statistic of 3.180685, exceeding the t-table value (1.96), and a p-value of 0.0016, which is below 0.05. This indicates that the presence of a sustainability committee or a higher level of a sustainability committee leads to increased carbon emission disclosure.
d. Profitability (K3) significantly affects carbon emission disclosure, with a t-statistic of -2.033345, which is greater in absolute terms than the t-table value (1.96) and a p-value of 0.0425, which is less than 0.05. This suggests that higher profitability tends to decrease carbon emission disclosure, indicating a negative relationship.
e. Managerial ownership (K4) has no significant impact on carbon emission disclosure decisions, with a t-statistic of -1.465738, which is lower in absolute terms than the t-table value (1.96) and a p-value of 0.1433, which is greater than 0.05.

4.2. Discusion

4.2.1. Gender diversity and carbon emission disclosure with company size, sustainability committee, profitability, and managerial ownership.

The results of the simultaneous test show an F-statistic of 15.11717 (P = 0.0000), indicating that gender diversity, company size, sustainability committee, profitability, and managerial ownership collectively

have a significant effect on carbon emission disclosure. This finding aligns with the research by Caby, Coron, and Ziane (2024) and Barroso, Duan, Guo, and Kowalewski (2024), which emphasizes the vital role of women in top management in enhancing environmental transparency. Furthermore, the influence of the control variables is supported by the literature, which states that company size (Kalu et al., 2016), profitability (Giannarakis, 2014), and sustainability committees (Cezanne, Lo, Kassi, & Rigot, 2025) are primary drivers of emission reporting. Theoretically, these results reinforce legitimacy theory, in which carbon emission disclosure is viewed as a strategic interaction between corporate governance, financial characteristics, and a company's oversight structure.

4.2.2. Gender Diversity and Carbon Emission Disclosure

The partial test results indicate that gender diversity does not have a significant effect on carbon emissions disclosure ($t = 0.2859$; $p = 0.775$). This finding contradicts Legitimacy yet it is consistent with the research of Gulo, Sari, Hapsari, and Tihar (2025) as well as Fadhlihi and Fatriansyah (2023).

This insignificant result challenges the assumptions of resource dependence theory in the Indonesian context, suggesting that the benefits of diverse perspectives are nullified when minority groups lack a critical mass. The findings strongly support the ' tokenism ' hypothesis, in which female directors are present merely to satisfy social expectations rather than to influence strategic decisions. The low representation of women (often below the 30% threshold) means that their aspirations are overshadowed by dominant group dynamics.

Consequently, for policymakers, these results imply that current 'soft law' approaches are insufficient. Future regulations must move beyond simple headcount quotas toward creating 'hard law' mandates (Healy, 2002) that ensure substantive participation. Without such structural support or the backing of specialized bodies like sustainability committees, gender diversity alone remains a symbolic attribute rather than an effective driver of environmental transparency

4.2.3. Company Size and Carbon Emission Disclosure

The partial test results show that company size does not significantly affect carbon emissions disclosure ($t = -0.1658$; $p = 0.8683$). This finding refutes the conventional assumption of legitimacy theory, as stated by Freedman and Jaggi (2005) and Kalu et al. (2016), which states that larger firms face greater public scrutiny and therefore utilize their excess resources for environmental transparency to maintain their social license to operate.

Furthermore, from an agency theory perspective, this result supports the arguments of Irwhantoko and Basuki (2016) and Gulo et al. (2025). It implies that, in the absence of strict enforcement, agents (managers) in large firms prioritize asset allocation towards immediate revenue-generating expansion rather than 'non-productive' voluntary disclosure. The critical implication for policymakers is that relying on the 'resource slack' of large corporations to drive voluntary sustainability is ineffective; thus, regulatory frameworks must shift from size-based expectations to uniform mandatory disclosure requirements across all scales of operation

4.2.4. Sustainability Committee and Carbon Emission Disclosure

The partial test results show that the sustainability committee has a positive and significant effect on carbon emissions disclosure ($t = 3.1807$; $p = 0.0016$). This finding confirms that the sustainability committee functions effectively as an internal oversight mechanism that promotes corporate transparency. This is in line with the study by Cezanne et al. (2025), who state that these committees are not merely symbolic ('window dressing') but are active organs that pressure management to reduce emissions intensity to maintain global legitimacy. Additionally, this finding strengthens the research by L. Liao et al. (2015), suggesting that specialized expertise within such committees ensures that technical carbon emissions issues receive higher priority than purely financial aspects.

Theoretically, this result provides robust empirical support for signaling theory. By establishing a dedicated committee, companies send a credible and costly signal to the market regarding their superior environmental quality, which helps differentiate them from less committed competitors. This

mechanism effectively reduces information asymmetry between management and shareholders, ensuring that disclosure serves as a genuine reflection of strategic commitment rather than a mere procedural formality.

4.2.5. Profitability and Carbon Emission Disclosure

Partial test results indicate that profitability has a negative and significant effect on carbon emissions disclosure ($t = -2.0333$; $p = 0.0425$). This finding indicates an anomaly in which increased profits decrease environmental transparency. Consistent with Giannarakis (2014), companies with high profitability tend to feel that they already possess strong economic legitimacy, thus limiting voluntary disclosure. Jiang, Li, and Sun (2024) add that highly profitable companies prioritize the allocation of funds for expansion or dividends over the high costs of carbon reporting audits. Furthermore, referring to Luo, Tang, and Lan (2013), this negative relationship indicates efforts by companies to conceal negative externalities to avoid regulator attention and carbon tax imposition.

Crucially, this finding necessitates a reinterpretation through the lens of agency theory. While traditional Agency Theory suggests that profitable firms signal quality to reduce agency costs, this negative correlation implies the dominance of 'managerial opportunism.' Managers (agents), driven by short-term financial incentives, view carbon disclosure as a 'proprietary cost' that could erode the bottom line and, consequently, their performance-based compensation. By withholding carbon information, agents attempt to maintain information asymmetry with shareholders (principals) to protect current profit margins from the potential financial liabilities associated with environmental transparency.

4.2.6. Managerial Ownership and Carbon Emission Disclosure

The partial test results show that managerial ownership does not have a significant effect on carbon emissions disclosure ($t = -0.3794$; $p = 0.1433$). This finding challenges the 'Convergence of Interest' hypothesis within agency theory, which traditionally posits that giving managers a stake in the company aligns their interests with shareholders and encourages long-term value creation. However, the insignificant result implies that, in the context of carbon reporting, managerial shareholding is insufficient to overcome the 'myopic' focus on short-term financial performance. An immaterial proportion of managerial shares fails to create sufficient incentives to prioritize costly environmental strategies over immediate profit maximization. In line with Al Amosh and Khatib (2022), the role of external monitoring and formal organizational structures proves to be more decisive than the individual financial incentives of managers.

The implications for corporate governance policy are clear: relying solely on standard equity ownership to drive sustainability is ineffective. Future governance mechanisms should consider tying executive compensation specifically to ESG performance targets (KPIs) rather than general share ownership. This approach would be more effective in bridging the agency gap, as the Indonesian capital market's orientation toward short-term profitability by Angela and Handoyo (2021) renders carbon issues a low priority for managers regardless of their ownership stake.

5. Conclusions

5.1. Conclusion

This study concludes that, simultaneously, all independent and control variables influence carbon emission disclosure. However, partially, only the sustainability committee and profitability have a significant effect. Gender diversity, company size, and managerial ownership are not proven to affect the level of emission transparency. Descriptive findings indicate that although disclosure practices appear relatively homogeneous, substantial disparities exist in governance structures and financial performance across sectors, leading to a widening transparency gap. Firms with stronger resources particularly those with dedicated sustainability committees and higher profitability tend to produce higher-quality disclosures. These findings highlight the need for regulatory intervention to ensure more equitable reporting practices. Additionally, increasing female board representation is not merely a compliance issue but contributes to improved decision-making quality through reduced groupthink and enhanced long-term risk orientation.

5.2. Research Limitations

This study has several limitations. First, the use of cross-sectional data limits the ability to capture dynamic changes in carbon disclosure practices over time. Second, the study focuses only on selected sectors, which may reduce the generalizability of the findings to other industries. Third, the variables used primarily reflect internal governance and financial factors, without fully incorporating external influences such as regulatory pressure, market expectations, or stakeholder activism. Finally, the measurement of carbon disclosure relies on available reports, which may contain subjectivity or inconsistencies across firms.

5.3. Suggestions and Directions for Future Research

Future research is recommended to expand the scope of analysis by including a broader range of industries and adopting longitudinal data to better capture trends in sustainability reporting. Researchers should also incorporate additional variables such as audit quality (e.g., external assurance of sustainability reports), stakeholder pressure (e.g., media exposure and institutional ownership), and regulatory enforcement to examine their influence on disclosure practices. From a practical perspective, companies are encouraged to strengthen sustainability governance structures and enhance gender diversity on boards to improve reporting quality. Regulators, particularly OJK and BEI, should establish standardized reporting frameworks aligned with international standards such as IFRS S2 and TCFD, provide technical training, and introduce incentives to encourage higher compliance and consistency in carbon disclosure.

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Author Contributions

II contributed to conceptualization, study design, data analysis, and manuscript drafting. MD was responsible for data collection, methodology development, and manuscript revision. GKPA contributed to data interpretation, supervision, and final approval of the manuscript. All authors have read and agreed to the published version of the manuscript.

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