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Determinants of Carbon Disclosure: Board Size and Financial Performance

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Abstract

Purpose: This study examines the influence of board characteristics (board size and gender diversity) and financial factors (profitability and leverage) on carbon-emission-disclosure practices among mining companies in an emerging market context.

Methodology: Employing a quantitative approach with a causal research design, this study analyzes secondary data from 50 firm-year observations of mining companies listed on the Indonesia Stock Exchange (IDX) from 2019 to 2023. Multiple linear regression analysis was performed using SPSS version 26.

Results: The findings reveal that board size has a significant positive influence on carbon emission disclosure ($\beta = 0.318$, $p < 0.05$), supporting agency theory. However, board gender diversity, profitability, and leverage have no significant influence on carbon disclosure practices.

Conclusions: This study concludes that larger boards are more effective in promoting carbon emission disclosure practices in Indonesian mining companies. The model explains 28.9% of the variance in the carbon emission disclosure.

Limitations: This study focuses exclusively on Indonesian mining companies over a five-year period, which may limit its generalizability.

Contributions: This study contributes to the environmental disclosure literature by providing empirical evidence from an emerging market context where carbon disclosure remains voluntary.

Keywords: *Board Gender Diversity, Board Size, Carbon Emission Disclosure, Corporate Governance, Leverage, Profitability*

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1. Introduction

Climate change is one of the most critical challenges facing humanity in the 21st century. According to the Intergovernmental Panel on Climate Change (IPCC, 2023), the global surface temperature has increased by approximately 1.1°C above pre-industrial levels, with human activities being the dominant cause. The Earth temperature has risen by 0.74°C over the past 300 years, primarily due to the accumulation of Greenhouse Gases (GHGs) such as Carbon Dioxide (CO_2), Methane (CH_4), and Nitrous Oxide (N_2O) in the atmosphere (World, 2024). This warming trend has triggered increasingly frequent and severe climate-related disasters, including extreme weather events, rising sea levels, and ecosystem disruptions, which threaten both human societies and natural systems worldwide.

The United Nations Framework Convention on Climate Change (UNFCCC) has emphasized the urgent need to limit the global temperature increase to 1.5°C above pre-industrial levels to avoid catastrophic climate impacts (UNFCCC, 2021) . However, recent data reveal concerning trends. June 2024 was recorded as the hottest month in history, with global average temperatures reaching 1.64°C above pre-industrial levels (World, 2024). This alarming statistic underscores the accelerating pace of climate change and the pressing need for immediate action across all sectors of society, particularly from industrial entities that are major contributors to greenhouse gas emissions.

The industrial sector, particularly energy-intensive industries such as mining, plays a significant role in global carbon emission. Clarkson, Li, Richardson, and Vasvari (2008) indicated that fossil fuel combustion and industrial processes account for approximately 75% of global CO_2 emissions. As the world's sixth-largest carbon emitter, Indonesia faces substantial challenges in managing its carbon footprint. The country's heavy reliance on coal for energy production has resulted in substantial emissions, with coal-based energy generation producing 404.6 million tons of CO_2 in 2022 alone, representing a 33.5% increase from the previous year. This dramatic increase highlights Indonesia's critical position in global climate discussions and the urgent need for improved environmental management and disclosure.

The mining sector in Indonesia is of particular economic and environmental significance. Mining companies are major contributors to the national economy, generating substantial revenue and employment opportunities. However, these economic benefits come with significant environmental costs, including habitat destruction, water pollution, and substantial carbon emissions. The extraction, processing, and transportation of minerals require enormous amounts of energy, predominantly derived from fossil fuels, making the mining sector one of the largest industrial contributors to greenhouse gas emissions in Indonesia. This dual nature of mining as both an economic driver and environmental burden creates complex challenges for policymakers, corporate managers and stakeholders concerned with sustainable development.

Against this backdrop, carbon emission disclosure has emerged as a critical mechanism for promoting corporate accountability and environmental stewardship in China. Carbon emission disclosure refers to the practice of companies reporting their greenhouse gas emissions and related environmental impacts through various channels, including annual and sustainability reports and dedicated environmental disclosures (Brammer & Pavelin, 2008). This transparency allows stakeholders including investors, regulators, customers, and the general public to assess companies' environmental performance and hold them accountable for their climate impact. Luo, Lan, and Tang (2012) demonstrated that carbon emission disclosure can influence corporate behavior, investment decisions, and market valuations, thereby serving as a powerful tool for promoting environmental responsibility.

However, despite growing international pressure and increasing stakeholder awareness of climate issues, carbon emission disclosures in Indonesia remain largely voluntary. Unlike mandatory financial reporting requirements, environmental disclosure, including carbon emissions, is not uniformly required by Indonesian regulations, although some sector-specific guidelines exist (Torchia, Calabrò, & Huse, 2011). This voluntary nature of disclosure creates significant variation in reporting practices, with many companies choosing minimal disclosure or avoiding it entirely because of concerns about costs, competitive disadvantage, or potential reputational risks associated with high emission levels (Anggraini, 2021). The voluntary framework also leads to inconsistent methodologies and metrics, making it difficult to compare environmental performance across companies or accurately assess sectoral trends.

Therefore, understanding the factors that influence carbon emission disclosure decisions is crucial for developing effective policies and practices to promote environmental transparency. Previous research has identified various corporate characteristics and governance mechanisms that may affect disclosure

behaviors. Among these, corporate governance factors have received considerable attention because they relate to decision-making structures and oversight mechanisms within organizations. Specifically, board characteristics, such as board size and gender diversity, have been proposed as important determinants of corporate environmental disclosure practices (Clarkson, Overell, & Chapple, 2011).

Board size, defined as the total number of directors serving on a company's board, may influence disclosure practices through various mechanisms. Larger boards potentially bring more diverse expertise, enhanced monitoring capabilities, and greater resources to address complex issues, such as environmental reporting (Dawkins & Fraas, 2011). Agency theory suggests that larger boards can better monitor management and reduce information asymmetry between corporate insiders and external stakeholders (Jensen & Meckling, 1976). In the context of environmental disclosure, a larger board may include directors with environmental expertise or stakeholder perspectives that promote transparency about carbon emissions. Conversely, some researchers argue that excessively large boards may suffer from coordination problems and diffusion of responsibility, potentially hindering effective decision-making on disclosure issues (Erika, Puspita, & Sagitaputri, 2019)

Board gender diversity, which refers to the presence of women on corporate boards, has also garnered significant research attention. Studies suggest that female directors may bring different perspectives, values, and decision-making styles to boardroom discussions. Specifically, research indicates that female directors tend to demonstrate greater concern for social and environmental issues, potentially leading to more comprehensive Corporate Social Responsibility (CSR) initiatives and environmental disclosures (Bear, Rahman, & Post, 2010; Glass, Cook, & Ingersoll, 2016). Stakeholder theory posits that boards with greater gender diversity may be more responsive to diverse stakeholder concerns, including environmental performance and transparency. However, empirical evidence on the relationship between board gender diversity and carbon emission disclosure remains mixed, with some studies finding positive associations and others reporting no significant effects on the relationship.

Beyond governance factors, the financial characteristics of companies may also influence their disclosure behavior. Profitability, measured by indicators such as Return on Assets (ROA) and Return on Equity (ROE), reflects a company's financial performance and resource availability. Legitimacy theory suggests that profitable companies have the resources and motivation to engage in voluntary disclosure practices that enhance their reputation and maintain social legitimacy (Deegan, 2002). Companies with strong financial performance may view carbon emission disclosure as an opportunity to demonstrate their commitment to sustainable practices and to differentiate themselves from less profitable competitors (Nurdiawansyah, Lindrianasari, & Komalasari, 2018). Additionally, profitable firms may face greater stakeholder scrutiny and public attention, creating pressure to proactively disclose environmental information.

Leverage, which represents the extent to which a company finances its operations through debt, may also affect disclosure practices. Companies with high leverage face greater scrutiny from creditors and may experience pressure to demonstrate responsible management practices, including environmental stewardship (Clarkson et al., 2008). However, high debt levels may also constrain the resources available for voluntary disclosure activities and environmental investments, potentially reducing disclosure incentives (Hogg, 2021). Furthermore, companies with significant debt obligations may prioritize financial performance over environmental transparency, particularly if disclosure reveals unfavorable information that could affect credit ratings or financing costs. Therefore, the relationship between leverage and carbon emission disclosure remains theoretically ambiguous and requires empirical investigation.

2. Literature Review and Hypotheses Development

2.1 Board Size and Carbon Emission Disclosure

Board size, typically measured as the total number of directors serving on the board, is an important corporate governance characteristic that may influence disclosure practices. From an agency theory perspective, larger boards can provide more effective monitoring of management actions and reduce information asymmetry between corporate insiders and external stakeholders (Fama & Jensen, 1983). More directors come with greater collective expertise, diverse perspectives, and an enhanced ability to oversee complex organizational issues, including environmental management and disclosure. Several empirical studies support the positive relationship between board size and carbon-emission disclosure. Yohanes (2021) found that larger boards in Indonesian companies were associated with more comprehensive carbon disclosures, arguing that size enables better monitoring and reduces information asymmetry. Similarly, Rona (2020) demonstrated that manufacturing companies with larger boards have higher levels of carbon emission disclosure, suggesting that board size enhances corporate transparency regarding environmental impacts. Internationally, Dawkins and Fraas (2011) examined Turkish companies and found that board size positively influenced carbon disclosure quality, with larger boards being more responsive to stakeholders' demands for environmental information.

The theoretical mechanisms linking board size and carbon disclosure are multifaceted. First, larger boards may include directors with specific expertise in environmental issues, sustainability, or stakeholder relations, bringing specialized knowledge that promotes environmental disclosures. Second, an increased board size enhances the monitoring capacity by distributing oversight responsibilities across more individuals, thereby reducing the likelihood that environmental issues will be overlooked . Third, larger boards may have stronger connections with external stakeholder groups, making them more aware of stakeholder expectations regarding carbon transparency (Pfeffer & Salancik, 1978). However, some researchers have raised concerns about the potential drawbacks of large boards. Zanra, Tanjung, and Silfi (2020) argued that excessively large boards may experience coordination problems, slower decision-making, and diffusion of responsibility, potentially offsetting the benefits of increased expertise and monitoring. In the Indonesian context, board size regulations and cultural factors related to board composition may also influence these dynamics. Despite these considerations, the preponderance of evidence suggests that, within reasonable limits, larger boards promote better environmental disclosure. Based on this theoretical reasoning and empirical evidence, we propose the following hypothesis:

H_1: Board size positively influences carbon emission carbon emission disclosure

2.2 Board Gender Diversity and Carbon Emission Disclosure

Board gender diversity refers to the representation of women on corporate boards and has become an important topic in corporate governance. Gender diversity in boardrooms is theorized to influence corporate behavior through multiple channels, including diverse perspectives, leadership styles, and priorities regarding corporate social responsibility. Research in psychology and organizational behavior suggests that women may bring distinct values and concerns to corporate decision-making, including heightened attention to social and environmental issues (Coffey & Wang, 1998). Several studies have documented a positive relationship between board gender diversity and carbon emission disclosure. Sindi and Yvonne (2019) found that the presence of female commissioners on Indonesian boards positively influenced carbon disclosure practices, suggesting that female directors enhance corporate environmental transparency. Similarly, Jessica and Herlin (2022) reported that Nigerian manufacturing firms with higher board gender diversity have better carbon disclosure practices. Glass, Cook, and Ingersoll (2016) provided evidence that female directors' concern for social and environmental issues translates into enhanced CSR reporting, including environmental disclosures.

The mechanisms through which gender diversity may enhance carbon disclosure are theoretically rich and varied. First, female directors may bring ethical perspectives that emphasize corporate responsibility and stakeholder welfare, promoting transparency regarding environmental impacts . Second, gender-diverse boards may exhibit different group dynamics, including more thorough discussions of complex issues and consideration of diverse stakeholder concerns. Third, the presence of women on boards may signal a company's commitment to diversity and inclusion, aligning with broader CSR orientations, including environmental disclosure (Bear, Rahman, & Post, 2010). Critical mass theory suggests that the influence of minority directors, including women, depends on achieving sufficient representation to impact board dynamics and decision-making (Torchia, Calabrò, & Huse, 2011). A single female director (tokenism) may have limited influence, whereas three or more female directors (critical mass) can shape board deliberations and outcomes. This implies that the relationship between gender diversity and carbon disclosure may be non-linear, with effects becoming more pronounced at higher levels of female representation. Despite these theoretical arguments and supporting evidence, some studies have found no significant relationship between board gender diversity and environmental disclosure, possibly due to contextual factors, measurement issues or threshold effects. Nevertheless, the theoretical rationale remains compelling, leading to the following hypothesis:

H_2: Board gender diversity positively influences carbon emission carbon emission disclosure

2.3 Profitability and Carbon Emission Disclosure

Profitability reflects a company's financial performance and its capacity to generate returns from its operations. Profitability, measured by indicators such as Return On Assets (ROA), Return On Equity (ROE), or profit margins, represents both the success of management strategies and the availability of resources for discretionary activities, including voluntary disclosure. The relationship between profitability and environmental disclosure has been extensively debated in the literature, with theoretical arguments supporting both positive and negative associations between the two.

From the perspective of legitimacy theory, profitable companies face greater stakeholder scrutiny and public attention, creating pressure to demonstrate social and environmental responsibility (Deegan, 2002). These companies may view carbon emission disclosure as an opportunity to enhance their reputation, build stakeholder trust, and maintain a social license to operate. Additionally, profitable firms possess the financial resources to invest in sophisticated environmental management systems, data collection infrastructure, and disclosure activities (Clarkson, Li, Richardson, & Vasvari, 2008) . The costs of carbon measurement, reporting, and verification can be substantial, potentially limiting disclosure among less-profitable companies.

Empirical evidence generally supports a positive relationship between profitability and carbon disclosure. Nurdiawansyah, Lindrianasari, and Komalasari (2018) found that Indonesian companies with higher profitability were more likely to disclose carbon emissions comprehensively. Anggraini (2021) similarly reported that profitable firms demonstrate better carbon disclosure practices, attributing this to resource availability and reputational motivations. Internationally, studies by Luo, Lan, and Tang (2012); Matsumura, Prakash, and Vera-Munoz (2014) have shown that profitable firms tend to engage more extensively in voluntary carbon disclosure, possibly to differentiate themselves and signal quality to stakeholders.

The resource-based view of firms provides additional theoretical support for this relationship. According to (Brammer & Pavelin, 2008) companies with superior resources and capabilities can invest in activities that create competitive advantages. Environmental disclosure capabilities, including measurement systems, reporting frameworks, and verification processes, constitute organizational resources that require financial investment to develop and maintain. Profitable companies are better positioned to make these investments and leverage environmental transparency as a source of competitive differentiation in an increasingly sustainability-conscious market.

However, alternative theoretical perspectives suggest possible negative or null relationships between these variables. Companies with poor environmental performance may use disclosure strategically to improve legitimacy, while highly profitable firms that are confident in their market position may see less need for voluntary disclosure. Despite these considerations, the predominant theoretical and empirical evidence supports a positive association, leading to the following hypothesis:

H_3: Profitability positively influences carbon emission disclosure

2.4 Leverage and Carbon Emission Disclosure

Leverage, defined as the extent to which a company uses debt to finance its operations, represents a fundamental aspect of the corporate financial structure with potential implications for disclosure behavior. Typically measured as the ratio of total debt to total assets or total equity, leverage reflects both a company's financing strategy and its financial risk profile. The theoretical relationship between leverage and carbon emission disclosure is complex and potentially ambiguous, with arguments supporting both positive and negative associations between them. On the one hand, agency theory suggests that companies with high leverage face heightened monitoring from creditors, who have financial interests at stake and seek information about factors that might affect the company's ability to repay debts (Jensen & Meckling, 1976). Environmental performance and carbon emissions may be relevant to creditors because environmental liabilities, regulatory sanctions, and reputational damage can impair financial performance and debt servicing capacity. To satisfy creditor information demands and maintain favorable relationships with lenders, highly leveraged companies may increase disclosure, including carbon emissions reporting .

Additionally, leveraged companies may strategically use environmental disclosures to signal creditworthiness and responsible management. By demonstrating attention to environmental risks and climate-related issues, companies can reduce perceived uncertainty and potentially secure more favorable financing terms . The growing emphasis on ESG factors in lending decisions and the emergence of green finance instruments further reinforce the incentives for leveraged companies to disclose their carbon emissions and demonstrate environmental stewardship.

Empirical studies have provided mixed evidence regarding this relationship. Anggraini (2021) found that leverage positively influences carbon emission disclosure among Indonesian companies, supporting the monitoring hypothesis.Erika, Puspita, and Sagitaputri (2019) similarly reported positive associations, suggesting that debt holders' information demands drive greater transparency. However, other studies, such as Septriyawati and Anisah (2019), found negative or insignificant relationships, possibly reflecting the constraining effects of debt on discretionary disclosure. However, high leverage may constrain the resources available for voluntary disclosure activities and environmental investments. Companies facing significant debt obligations may prioritize financial performance and debt services over investments in sustainability reporting systems and verification processes. Furthermore, if carbon disclosure reveals unfavorable environmental performance or substantial climate-related risks, highly leveraged companies may avoid disclosure to prevent adverse effects on credit ratings, borrowing costs, or debt covenant compliance (Clarkson, Li, Richardson, & Vasvari, 2008). Despite the theoretical ambiguity, monitoring and signaling arguments suggest that leverage should promote carbon disclosure, particularly in contexts where creditors value environmental information. Based on this reasoning and consistent with recent empirical evidence, we propose the following hypothesis:

H_4: Leverage has a negative influence on carbon emission disclosure

3. Methodology

3.1 Research Design

This study employs a quantitative research design with a causality approach to examine the relationships between board size, board gender diversity, profitability, leverage, and carbon emission disclosure. Quantitative research is appropriate for investigating relationships between measurable

variables using numerical data and statistical analysis. The causality approach specifically focuses on identifying and testing cause-and-effect relationships between independent and dependent variables, allowing us to assess whether changes in board characteristics and financial factors are associated with variations in carbon disclosure practice. This study follows a deductive approach, beginning with theoretical frameworks and existing literature to develop hypotheses, and then collecting and analyzing empirical data to test these hypotheses. This approach is consistent with the positivist research philosophy, which assumes that social phenomena can be studied objectively through observation and measurement and that relationships between variables can be identified through systematic investigation.

3.2 Population and Sample

The research population comprises all companies in the mining sector listed on the Indonesia Stock Exchange (IDX) during the period 2019-2023. The mining sector was selected for several strategic reasons. First, mining companies are among the largest industrial contributors to carbon emissions in Indonesia, making them particularly relevant for studying carbon-disclosure practices. Second, mining operations have significant environmental impacts and stakeholder scrutiny, creating strong pressure for environmental transparency. Third, the mining sector has received increasing regulatory and public attention regarding environmental performance, particularly following environmental incidents and climate change concerns. The five-year period from 2019 to 2023 was selected to capture recent trends in carbon disclosure while providing sufficient observations for a robust statistical analysis. This period is particularly relevant as it includes the years following Indonesia's ratification of the Paris Agreement and increasing global attention to climate change and corporate environmental responsibility. The timeframe also encompasses the COVID-19 pandemic period (2020-2021), which may have influenced corporate disclosure practices due to shifts in stakeholder priorities and resource constraints.

Sample selection employed a purposive sampling technique, a non-probability sampling method in which samples are selected based on specific criteria relevant to the research objectives. Purposive sampling is appropriate when the researcher needs to ensure that the selected cases meet particular characteristics necessary for addressing the research questions. The following criteria were applied in this study:

1. Companies classified in the mining sector and listed on the IDX continuously throughout the 2019-2023 period, ensuring consistent industry context and data availability.
2. Companies that published complete annual financial reports during the observation period provided the necessary financial data for the independent variables.
3. Companies that published sustainability reports or integrated annual reports containing carbon emission information during the observation period, enabling the measurement of the dependent variable.
4. Companies with complete information regarding board composition, including board size and gender composition, are necessary for measuring key independent variables.
5. Companies report financial data in Indonesian Rupiah and use consistent accounting standards to ensure the comparability of financial metrics.

The application of these criteria resulted in a final sample of 10 mining companies observed over five years, yielding 50 firm-year observations. While this sample size may appear modest, it represents a substantial portion of mining companies that meet the disclosure criteria and is adequate for the chosen statistical analysis method. The sample size is comparable to or exceeds that of many prior studies on carbon disclosure in emerging markets, where voluntary disclosure remains limited

3.3 Data Collection and Sources

This study uses secondary data obtained from published corporate documents available on the IDX website and individual company websites. Secondary data are appropriate for this study because they provide objective, verified information about company characteristics, financial performance, and disclosure practices. The use of archival data also allows for longitudinal analysis and eliminates potential biases associated with primary data collection, such as survey responses. Three main types of documents were collected for each company and year: annual financial reports, which provide information on financial performance, leverage, and other financial metric, sustainability or corporate social responsibility reports, which contain carbon emission disclosures and environmental information, and annual reports containing corporate governance information, including board composition and structure. When sustainability information was integrated into annual reports rather than published separately, the integrated annual report served as the primary data source. Data collection was conducted systematically. First, a list of mining companies listed on the IDX during 2019-2023 was obtained from the IDX website. Second, annual and sustainability reports for each company were downloaded from company websites or the IDX database. Third, relevant information for each variable was extracted and recorded using a structured data collection sheet. Fourth, the data were verified for completeness and consistency, with any missing or unclear information cross-checked against multiple sources. This systematic approach ensured data quality and reliability for subsequent analyses.

3.4 Variables and Operational Definitions

3.4.1 Dependent Variable: Carbon Emission Disclosure

The dependent variable in this study is carbon emissions disclosure, measured using a disclosure index based on the Carbon Disclosure Project (CDP) framework. The CDP framework is internationally recognized and provides comprehensive guidelines for corporate carbon reporting (Luo, Lan, & Tang, 2012). Following previous research by Choi, Lee, and Psaros (2013), we developed a disclosure index consisting of 18 items that cover various aspects of carbon emission reporting.

The disclosure items include a statement of climate change commitment, description of risks related to climate change, opportunities related to climate change, Scope 1 emissions (direct emissions from owned or controlled sources), Scope 2 emissions (indirect emissions from purchased electricity), Scope 3 emissions (other indirect emissions in the value chain), historical emission trends, emission reduction targets, emission reduction strategies and initiatives, carbon intensity metrics, verification or assurance of emission data, participation in emission trading schemes, emission sources breakdown, energy consumption data, renewable energy use, climate change governance structure, accountability for climate change issues, and stakeholder engagement on climate issues. Each item was coded dichotomously, with a score of 1 assigned if the item was disclosed and 0 if it was not disclosed. The overall disclosure index was calculated by summing the scores and dividing by the maximum possible score (18), resulting in a percentage score ranging from 0% (no disclosure) to 100% (complete disclosure). This approach follows established practices in disclosure research and enables comparative analysis across companies and over time periods Choi et al. (2013);Luo et al. (2012). The Formula 1 is:

$$CarbonEmissionDisclosureIndex = (\sum Xi/n) \times 100 \quad (1)$$

Where Xi represents each disclosure item (1 if disclosed, 0 if not), and n represents the total number of disclosure items (18).

3.4.2 Independent Variables

Board Size: Measured as the total number of directors serving on the board of directors and board of commissioners at the end of each fiscal year. This measure captures the overall size of board governance. Following Indonesian corporate governance regulations, both the board of directors (*Direksi*) and the board of commissioners (*Dewan Komisaris*) are included in the total count, as both play important governance roles.

Board Gender Diversity: Measured as the proportion of female directors on the board, calculated as the number of female directors divided by the total board size. This ratio, ranging from 0 to 1 (or 0% to 100%), captures the extent of gender diversity in board composition. Following the research by Bear, Rahman, and Post (2010), the proportion measure is preferred over absolute numbers because it accounts for differences in board size across companies. The Formula 2 is:

$$BoardGenderDiversity = NumberofFemaleDirectors/TotalNumberofDirectors \quad (2)$$

Profitability: Measured using Return on Assets (ROA), calculated as net income divided by total assets. ROA indicates how efficiently a company utilizes its assets to generate profits and is widely used in corporate finance and accounting studies. This metric is particularly appropriate for cross-company comparisons because it is standardized by the asset base. The Formula 3 is:

$$ROA = (NetIncome/TotalAssets) \times 100 \quad (3)$$

Leverage: Measured as the debt-to-asset ratio (DAR), calculated as total liabilities divided by total assets. This ratio indicates the proportion of assets financed through debt and represents a company's financial leverage. DAR is commonly used in financial analysis and is particularly relevant for assessing financial risk and creditor-monitoring intensity. The Formula 4 is:

$$DAR = (TotalLiabilities/TotalAssets) \times 100 \quad (4)$$

3.5 Data Analysis Technique

Data analysis was conducted using multiple linear regression analysis with SPSS Statistics (version 26). Multiple regression is appropriate for examining the simultaneous influence of multiple independent variables on a dependent variable while controlling for the effects of other variables (Hair, Risher, Sarstedt, & Ringle, 2019). Before conducting the regression analysis, several classical assumption tests were performed to ensure the validity of the regression model.

3.5.1 Descriptive Statistics

Descriptive statistics were calculated to provide an overview of the data characteristics, including the mean, standard deviation, minimum, and maximum values for all variables. This preliminary analysis helps identify data patterns, potential outliers, and the overall distribution of the variables.

3.5.2 Classical Assumption Tests

Normality test: The Kolmogorov-Smirnov test was used to assess whether the residuals followed a normal distribution. A normal distribution of residuals is required for valid statistical inference in regression analysis (Ghozali, 2020). If the significance value exceeds 0.05, the residuals are considered to be normally distributed.

Multicollinearity Test: Variance Inflation Factor (VIF) and tolerance values were examined to detect multicollinearity among the independent variables. VIF values below 10 and tolerance values above

0.10 indicate acceptable levels of multicollinearity (Hair, Risher, Sarstedt, & Ringle, 2019). High multicollinearity can inflate the standard errors and reduce the reliability of the coefficient estimates.

Heteroscedasticity Test: The Glejser test was employed to detect heteroscedasticity, which refers to the non-constant variance of residuals across observations. Homoscedasticity (constant variance) is assumed in regression analysis; if the Glejser test yields significance values above 0.05, heteroscedasticity is not present (Ghozali, 2020).

Autocorrelation test: The Durbin-Watson test was used to detect autocorrelation in the residuals. Autocorrelation can occur in panel data when observations from the same firm are not independent across different years. Durbin-Watson values between 1.5 and 2.5 generally indicate no significant autocorrelation (Ghozali, 2020).

3.5.3 Hypothesis Testing
The regression model tested in this study is specified as follows Formula 5 :

$$CED = \alpha + \beta_1 BS + \beta_2 BGD + \beta_3 PROF + \beta_4 LEV + \varepsilon \quad (5)$$

Model Fit Test (F-test): The F-test assesses whether the regression model as a whole is statistically significant, testing whether at least one independent variable has a significant effect on the dependent variable. If the F-statistic's significance value is below 0.05, the model is considered significant (Hair, Risher, Sarstedt, & Ringle, 2019). Coefficient of Determination (R^2): The adjusted R^2 value indicates the proportion of the variance in carbon emission disclosure explained by the independent variables. Values closer to 1 indicate that the model explains a large proportion of the variance in the dependent variable (Ghozali, 2020). Individual Coefficient Tests (t-tests): T-tests were conducted to assess the significance of each independent variable's effect on carbon emission disclosure. Hypotheses are supported when the t-statistic's significance value is below 0.05 (for two-tailed tests) or when the coefficient sign matches the predicted direction. This test allows us to determine which specific factors significantly influence the carbon disclosure practices.

4. Results and Discussions

4.1 Descriptive Statistics

The descriptive statistics show that carbon-emission disclosure among mining companies varies considerably, with a mean disclosure score of 0.65 (SD = 0.18). The board size ranges from 3 to 12 members, with a mean of 6.8 members (SD = 2.1). Board gender diversity shows an average proportion of 0.22 (SD = 0.15), indicating that approximately 22% of board members are women. Profitability (ROA) ranges from -5.2% to 18.3%, with a mean of 8.6% (SD = 5.4%). Leverage (DER) varied from 0.35 to 2.84, with a mean of 1.23 (SD = 0.67).

4.2 Classical Assumption Tests

Classical assumption tests were conducted to ensure the validity of the regression model. The normality test using the Kolmogorov-Smirnov test showed that the data were normally distributed ($p > 0.05$). The multicollinearity test indicated that all VIF values were below 10 and tolerance values were above 0.1, confirming no multicollinearity issues. The heteroscedasticity test using the Glejser test showed no heteroscedasticity ($p > 0.05$). The autocorrelation test using the Durbin-Watson statistic showed a value of 1.89, which is within the acceptable range, indicating that there was no autocorrelation.

4.3 Hypothesis Testing Results

The multiple linear regression analysis results show that the model is significant ($F = 4.582$, $p < 0.01$) with an R^2 value of 0.289, indicating that 28.9% of the variance in carbon emission disclosure can be explained by the independent variables. The detailed results for each hypothesis are as follows :

H_1: Board size has a significant positive influence on carbon emission disclosure (β = 0.318, t = 2.456, p < 0.05). This supports Hypothesis 1
H_2: Board gender diversity does not significantly influence carbon emission disclosure (β = 0.124, t = 1.087, p > 0.05). This does not support hypothesis 2
H_3: Profitability does not significantly influence carbon emission disclosure (β = 0.089, t = 0.745, p > 0.05). This finding does not support hypothesis 3
H_4: Leverage does not significantly influence carbon emission disclosure (β = -0.056, t = -0.423, p > 0.05). This finding does not support hypothesis 4

4.4 Discussion

The findings of this study provide several important insights into the factors influencing carbon emission disclosure in Indonesian mining companies. The significant positive influence of board size on carbon emission disclosure aligns with agency theory Jensen and Meckling (1976); Fama and Jensen (1983) and resource dependence theory (Pfeffer & Salancik, 1978); (Hillman & Dalziel, 2003), suggesting that larger boards provide better monitoring capabilities and access to diverse resources and expertise (Sri & Pikar, 2020); (Yohanes, 2021).

This finding is consistent with previous research by (Sindi & Yvonne, 2019), who found that companies with larger boards are more transparent about environmental issues. The lack of significant influence of board gender diversity on carbon emission disclosure contradicts some previous studies (Yumna & Doddy, 2021);(Liao, Luo, & Tang, 2015) but aligns with the findings of (Herinda, Nurlaela, & Titisari, 2021). This result may be explained by the relatively low proportion of female directors in Indonesian mining companies (mean of 22%), which may not be sufficient to reach the critical mass necessary to significantly influence disclosure decisions (Post, Rahman, & Rubow, 2011). According to the critical mass theory, a minimum threshold of female board representation (typically around 30%) is required before women can effectively influence board decisions (Torchia, Calabrò, & Huse, 2011).

The insignificant influence of profitability on carbon emission disclosure is surprising, given that legitimacy theory suggests that profitable companies have greater incentives for environmental disclosure (Suchman, 1995);(Deegan, 2002). However, this finding is consistent with those of recent studies by (Jessica & Herlin, 2022) . One possible explanation is that companies in the mining sector may prioritize other strategic initiatives over environmental disclosure, regardless of profitability levels. The lack of mandatory carbon disclosure requirements in Indonesia may reduce profitable firms' motivation to voluntarily disclose environmental information (Hahn, Reimsbach, & Schiemann, 2015).

Similarly, leverage has no significant influence on carbon emission disclosure, which contradicts the predictions of agency theory (Jensen & Meckling, 1976). This finding aligns with those of Jessica and Herlin (2022);Herinda et al. (2021), who also found no significant relationship. This result suggests that debt levels may not be a primary driver of environmental disclosure decisions in the Indonesian mining sector, possibly because creditors may focus more on financial rather than environmental information when making lending decisions (Clarkson, Li, Richardson, & Vasvari, 2008).

5. Conclusions

5.1 Conclusion

This study examined the influence of board size, board gender diversity, profitability, and leverage on mining companies' carbon emission disclosure on the Indonesia Stock Exchange during 2019-2023. Based on the analysis of 50 firm-year observations, several key conclusions were drawn. First, board size has a significant positive effect on carbon emission disclosure. Companies with larger boards demonstrate more comprehensive carbon disclosure practices, supporting the theoretical argument that larger boards bring greater expertise, enhanced monitoring capabilities, and broader stakeholder perspectives that promote environmental transparency. This finding highlights the important role

of corporate governance structures, particularly board composition, in shaping environmental disclosure.

Second, board gender diversity does not significantly influence carbon emission disclosure in this sample. Although the coefficient is positive, suggesting a directional relationship consistent with theoretical expectations, the effect is not statistically significant. This may reflect the relatively low levels of female board representation in the sample, insufficient to reach the critical mass necessary for a meaningful influence, or industry-specific factors that moderate the relationship between gender diversity and environmental disclosure.

Third, profitability does not significantly influence the disclosure of carbon emissions. Despite theoretical arguments suggesting that profitable companies should engage more extensively in voluntary disclosure, empirical evidence from this sample does not support this relationship. This may reflect the competing pressures facing profitable mining companies, the influence of commodity price volatility on profitability that obscures relationships with disclosure, or strategic considerations that make profitable companies no more inclined to disclose carbon information than their less profitable counterparts.

Fourth, leverage does not significantly influence carbon emission disclosure. Although the coefficient is positive, consistent with creditor monitoring arguments, the effect is insignificant. This suggests that debt financing, at least as measured by the debt-to-asset ratio, does not create sufficient pressure or incentives for enhanced carbon disclosure in Indonesia mining sector.

5.2 Research Limitations

This study had several limitations. First, it focuses only on mining companies in Indonesia, which may limit the generalizability of the findings to other sectors or countries. Second, the study examines only four variables (board size, board gender diversity, profitability, and leverage), while other potentially relevant factors such as company size, environmental policy, ownership structure, and institutional pressure are not included. Third, measuring carbon emission disclosure using a disclosure index may not fully capture the quality of the disclosed information.

5.3 Suggestions and Directions for Future Research

Future research should address these limitations by examining other sectors, incorporating additional variables such as board independence, environmental committees, and stakeholder pressure, employing alternative measurement methods, including content analysis and assurance of sustainability reports, and using longitudinal designs to capture temporal dynamics in disclosure practices. Additionally, comparative studies across countries would enhance the understanding of environmental disclosure practices in diverse institutional contexts.

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