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Econometric panel data modeling of corporate carbon emission disclosure: Financial and environmental determinants in the mining industry

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Abstract

Background: The growing urgency of climate change mitigation has intensified global attention on corporate transparency in carbon emission reporting. Companies operating in carbon-intensive industries, particularly the mining sector, face increasing pressure from regulators, investors, and the public to disclose environmental impacts in a systematic and accountable manner. However, empirical evidence explaining the determinants of corporate carbon emission disclosure remains limited, especially in emerging economies where sustainability reporting practices are still evolving.
Aims: This study aims to develop an econometric panel data model to examine the influence of financial performance and environmental performance on corporate carbon emission disclosure, while also assessing the moderating role of firm size in strengthening disclosure behaviour.
Methods: The research employs a quantitative approach using panel data econometric modelling. The dataset includes 40 mining companies listed on the Indonesia Stock Exchange during the period 2018–2024, generating 280 firm-year observations. Carbon emission disclosure is measured using a disclosure index, financial performance is proxied by return on equity, environmental performance is represented by the PROPER rating, and firm size is measured by the natural logarithm of total assets. The analysis applies a Fixed Effect Model with robust standard errors to control for unobserved firm heterogeneity.
Result: The results show that financial performance and environmental performance significantly increase corporate carbon emission disclosure. In addition, firm size strengthens the relationship between environmental performance and disclosure intensity.
Conclusion: The findings demonstrate that carbon disclosure is shaped by financial capability, environmental governance, and organizational scale. Firms with stronger financial capacity and better environmental performance tend to disclose carbon information more transparently, while larger firms respond more strongly to environmental accountability pressures. These results contribute to data-driven sustainability research and highlight the importance of strengthening environmental governance and transparent carbon reporting in emission-intensive industries.

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INTRODUCTION

Climate change has become one of the most pressing global challenges, encouraging governments, industries, and international institutions to intensify efforts toward carbon reduction and sustainable economic development. In this context, corporate transparency regarding carbon emissions has emerged as a key element of environmental governance and sustainability accountability. Companies operating in carbon-intensive industries, particularly the mining sector, are increasingly expected to disclose environmental information related to carbon emissions as part of responsible corporate practices. Transparent carbon emission disclosure not only reflects

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regulatory compliance but also functions as a mechanism for improving corporate legitimacy and stakeholder trust. Investors, regulators, and environmental organizations now rely on corporate environmental reporting to evaluate how firms manage climate-related risks and environmental impacts. Recent studies emphasize that financial systems, technological innovation, and industrial transformation play an important role in shaping environmental sustainability and carbon reduction initiatives (Huang et al., 2025 and Y. Wang et al., 2024). Other research also highlights that sustainability governance and environmental policies influence how firms respond to environmental pressures and manage emission-related risks (AlHares, 2025 and Zhang, 2024). Despite the growing importance of carbon transparency, understanding the internal corporate factors that influence carbon emission disclosure remains an important challenge in sustainability research.

The increasing integration of sustainability concerns into corporate governance has created a growing need to understand the determinants of corporate environmental disclosure. Companies today face simultaneous pressures to maintain financial performance while demonstrating commitment to environmental responsibility and sustainability standards. Financial performance often determines whether firms possess sufficient resources to support environmental monitoring systems and sustainability reporting practices. Firms with stronger financial capacity may allocate more resources to environmental management and disclosure activities in order to strengthen their corporate reputation and legitimacy. At the same time, environmental performance can encourage companies to communicate their sustainability achievements through voluntary disclosure mechanisms. Previous studies indicate that financial innovation, green finance policies, and technological transformation influence corporate responses to environmental challenges and decarbonization efforts (Chen et al., 2024 and Yang et al., 2025). In addition, the development of sustainability governance frameworks and ESG-oriented management practices has been found to shape corporate environmental behaviour and emission management strategies (Alnafrah, 2024 and Yu et al., 2024). However, empirical evidence that integrates financial performance, environmental performance, and organizational characteristics such as firm size in explaining corporate carbon emission disclosure remains limited.

Recent sustainability studies increasingly highlight the role of financial, technological, and governance mechanisms in supporting environmental responsibility and decarbonization processes across industries. Konat et al., (2026) demonstrate that financial investments in advanced technologies can significantly influence corporate carbon footprints within industrial economies. Cai et al., (2026) further show that digitalization and financial innovation support low-carbon industrial transformation and facilitate sustainable technological development. Empirical evidence from regional economic studies also indicates that financial development contributes to improved environmental outcomes and sustainability performance (Satanbekov et al., 2026). Research focusing on resource-intensive industries suggests that financial innovation and Industry 4.0 technologies accelerate decarbonization processes and reduce carbon intensity (Khan et al., 2026). Studies by Liu et al., (2025) emphasize that financial development and energy transition policies significantly influence environmental sustainability in emerging economies. Dai et al., (2025) also report that carbon risk pressures can encourage firms to engage in environmental signalling and disclosure practices within capital markets. Zhou et al., (2025) highlight the importance of digital climate governance frameworks in supporting carbon neutrality and technological progress. Additional studies underline the importance of sustainability governance mechanisms, environmental standards, and green finance policies in improving corporate environmental performance (Tergu et al., 2025 and W. Wang et al., 2025). Although these studies provide valuable insights into environmental sustainability and carbon management, relatively few empirical studies examine how financial performance and environmental performance simultaneously influence firm-level carbon emission disclosure behaviour.

Although previous studies have provided important insights into environmental governance and decarbonization strategies, several research gaps remain evident in the existing literature. Many prior studies focus on macro-level analyses such as regional emissions, national sustainability policies, or industry-level decarbonization trends. Firm-level research examining the determinants of corporate carbon emission disclosure remains relatively limited, particularly within emission-intensive sectors. In addition, previous studies often analyze financial factors or environmental performance separately rather than integrating both variables within a unified empirical framework. The moderating role of organizational characteristics such as firm size in influencing disclosure behaviour is also rarely examined in sustainability research. Furthermore, a large portion of existing research relies on cross-sectional approaches rather than longitudinal panel data analysis capable of capturing dynamic corporate behaviour over time. Without longitudinal econometric modelling, it becomes difficult to identify how internal corporate capabilities influence environmental transparency. These limitations reduce the ability of current literature to explain corporate carbon disclosure behaviour comprehensively. Addressing these gaps is therefore essential to strengthen empirical understanding of the determinants of corporate carbon emission disclosure.

Based on the identified research gaps, this study aims to develop an econometric panel data model to analyse the determinants of corporate carbon emission disclosure within the mining industry. The research specifically investigates the influence of financial performance and environmental performance on the level of carbon emission disclosure among mining companies. In addition, the study examines whether firm size strengthens the relationship between environmental performance and disclosure behaviour. By applying panel data econometric modelling, this research provides empirical evidence based on longitudinal firm-level observations. The analysis uses data from mining firms listed on the Indonesia Stock Exchange during the period 2018–2024. Through this approach, the study aims to provide robust analytical insights regarding the drivers of environmental transparency in emission-intensive industries. The research contributes to sustainability and environmental governance literature by integrating financial capability, environmental responsibility, and organizational characteristics within a unified empirical framework. Ultimately, the findings are expected to support the development of transparent corporate carbon reporting and strengthen data-driven sustainability governance.

METHOD

Research Design

This study employs a quantitative research design based on econometric panel data modelling to investigate the determinants of corporate carbon emission disclosure in the mining industry. Quantitative econometric approaches are widely applied in environmental and sustainability research because they allow researchers to analyse relationships among financial, environmental, and organizational variables across time and across firms. Panel data modelling is particularly useful for examining corporate environmental behaviour since it captures both cross-sectional variation among firms and longitudinal variation across different observation periods. In sustainability research, econometric panel analysis is often used to evaluate environmental governance and decarbonization strategies within industrial sectors, as demonstrated in studies examining environmental sustainability and financial development (Li et al., 2025 and Zameer et al., 2023). The panel modelling approach enables the analysis to control for firm-specific characteristics that cannot be observed directly but may influence disclosure behaviour. This approach therefore improves estimation accuracy compared with traditional cross-sectional regression models. By integrating financial performance, environmental performance, and firm characteristics into a unified analytical framework, the study adopts a data-driven modelling strategy consistent with emerging

sustainability research. Consequently, the research design provides a rigorous analytical foundation for understanding the determinants of corporate carbon emission disclosure in emission-intensive industries.

Participants

The participants in this study consist of mining companies listed on the Indonesia Stock Exchange during the period 2018–2024. The mining sector was selected because it represents one of the most environmentally sensitive industries due to its substantial contribution to greenhouse gas emissions and environmental degradation. Previous studies on industrial decarbonization highlight that resource-intensive sectors play a crucial role in global carbon reduction strategies and environmental governance frameworks (Fu & Zailani, 2025 and Jiang et al., 2024). The sample selection process applies purposive sampling to ensure that firms included in the dataset provide complete financial reports, environmental performance ratings, and sustainability disclosure information. Companies lacking consistent reporting during the observation period were excluded in order to maintain data reliability and comparability. After the screening process, the final sample consists of 40 mining companies. These companies were observed over a seven-year period from 2018 to 2024. The dataset therefore forms a balanced panel consisting of 280 firm-year observations that enable longitudinal econometric analysis of corporate environmental disclosure behaviour.

Instrument

This study relies on secondary data collected from publicly available corporate and institutional sources. Data on carbon emission disclosure are obtained from corporate annual reports and sustainability reports published by the sampled firms. Financial performance data are extracted from audited financial statements available through company disclosures and stock exchange databases. Environmental performance data are obtained from the PROPER environmental rating system issued by the Indonesian Ministry of Environment and Forestry. Previous environmental governance studies frequently employ financial and environmental indicators to examine corporate sustainability behaviour and environmental performance outcomes (Lin & Qamruzzaman, 2023 and Velte, 2024). Carbon emission disclosure is measured using a disclosure index that evaluates the extent to which firms report carbon-related environmental information. Financial performance is measured using Return on Equity (ROE), which represents corporate profitability and financial capability. Environmental performance is proxied by the PROPER rating, while firm size is measured using the natural logarithm of total assets to represent the scale of corporate operations.

Operational Definition of Variables

Table 1. Operational Definition of Variables

Variable	Proxy / Measurement	Description
Carbon Emission Disclosure (CED)	Disclosure Index	Measures the extent of carbon emission information reported in corporate reports
Financial Performance (ROE)	Return on Equity	Indicates corporate profitability and financial capacity
Environmental Performance (EP)	PROPER Rating	Government environmental rating evaluating corporate environmental management
Firm Size (SIZE)	Ln (Total Assets)	Represents the scale of corporate operations

The empirical analysis is conducted using panel data econometric modelling to estimate the influence of financial and environmental factors on corporate carbon emission disclosure. Panel econometric techniques are particularly appropriate for sustainability research because they enable researchers to analyse corporate environmental behaviour across multiple firms and over multiple time periods. Previous environmental governance studies frequently employ panel modelling to

examine the relationships between financial development, environmental policy, and sustainability outcomes (Solaymani & Montes, 2024 and Xu et al., 2022). The analysis begins with descriptive statistics to summarize the distribution and characteristics of the research variables. Correlation analysis is subsequently performed to examine the preliminary relationships between financial performance, environmental performance, firm size, and carbon disclosure. Econometric model selection is conducted using the Chow test and Hausman test to determine the most appropriate panel regression specification. Based on the results of these tests, the Fixed Effect Model is selected to control for unobserved firm heterogeneity. Robust standard errors are applied to address potential heteroskedasticity and improve the reliability of the estimated coefficients.

Econometric Model Specification

The econometric model used in this study is expressed as follows:1

$$CEDit=\alpha+\beta 1ROEit+\beta 2EPit+\beta 3SIZEit+\beta 4(EPit\times SIZEit)+\varepsilon it$$

Where:

- **CED** = Carbon Emission Disclosure
- **ROE** = Financial Performance
- **EP** = Environmental Performance
- **SIZE** = Firm Size
- **EP × SIZE** = Interaction variable (moderating effect)
- **i** = firm
- **t** = year

The econometric model estimates both the direct and moderating effects among the variables included in the analysis. Financial performance represents the economic capability of firms to invest in sustainability initiatives and environmental reporting systems. Environmental performance reflects the effectiveness of corporate environmental management practices and regulatory compliance. Firms that achieve stronger environmental performance may be more willing to disclose carbon emission information as a signalling mechanism to stakeholders. Firm size is incorporated in the model to capture the influence of organizational scale on corporate transparency and environmental accountability. Larger firms usually face stronger regulatory scrutiny and greater reputational risks related to environmental issues. Consequently, large companies tend to disclose environmental information more extensively than smaller firms. The interaction term between environmental performance and firm size allows the study to evaluate whether organizational scale strengthens the relationship between environmental performance and carbon disclosure.

Conceptual Framework

Figure 1. Research Conceptual Model

Figure 1. illustrates the theoretical relationships examined in this study regarding the determinants of corporate carbon emission disclosure in the mining industry. The model proposes that financial performance, measured by Return on Equity (ROE), directly influences the level of carbon emission disclosure because firms with stronger profitability generally possess greater resources to support sustainability reporting and environmental transparency. Environmental performance, represented by the PROPER rating, is also hypothesized to directly influence carbon disclosure since firms with better environmental management practices tend to communicate their environmental responsibility through corporate reporting. In addition to these direct relationships, firm size is included in the model as both an explanatory and moderating variable. Larger firms often face greater regulatory scrutiny and public pressure regarding environmental accountability, which may encourage more comprehensive disclosure practices. The moderating relationship between firm size and environmental performance suggests that the effect of environmental performance on disclosure behaviour may be stronger for larger companies. This conceptual framework therefore integrates financial capability, environmental governance, and organizational scale into a unified analytical structure. The model provides the basis for the econometric panel data analysis used to evaluate the direct and interaction effects among the variables. Through this framework, the study aims to generate empirical evidence explaining how corporate characteristics influence carbon emission disclosure in emission-intensive industries.

RESULTS AND DISCUSSION

Results

The empirical analysis begins with descriptive statistics that summarize the distribution of the research variables used in the panel regression model. The dataset consists of 40 listed firms observed over seven years, resulting in a balanced panel of 280 firm–year observations. Carbon emission disclosure exhibits a mean value of 0.5128 with a standard deviation of 0.2678, indicating moderate variation in disclosure practices across firms. Financial performance measured by return on equity shows an average value of 0.2133 with substantial dispersion, reflecting differences in profitability among the sampled companies. Environmental performance proxied by the government PROPER rating records an average score of 3.6679, indicating that most firms fall within the moderate environmental performance category. Firm size measured using the natural logarithm of total assets has a mean of 12.9980, suggesting that the majority of the sampled firms are relatively large organizations. The minimum and maximum values indicate a wide variation in both environmental performance and financial indicators across the sample. Overall, the descriptive statistics demonstrate sufficient variability across observations, supporting the suitability of the dataset for panel regression analysis.

Table 2. Descriptive Statistics of Research Variables

Variable	Observations	Mean	Std. Dev.	Minimum
Carbon Emission Disclosure (CHOI)	280	0.5128	0.2678	0.0556
Financial Performance (ROE)	280	0.2133	1.6844	-2.5434
Environmental Performance (PROPER)	280	3.6679	0.7900	2.0000
Firm Size (Ln Total Assets)	280	12.9980	0.6534	11.3695

The descriptive results indicate that environmental disclosure practices vary substantially across firms, reflecting differences in corporate transparency and environmental responsibility. In addition, the relatively high dispersion in financial performance suggests that firms in the sample operate under heterogeneous financial conditions.

Before estimating the regression model, panel data diagnostic tests were conducted to determine the most appropriate estimation approach. The Chow test comparing the common effects model and the fixed effects model produced a probability value of 0.0000, indicating that the fixed

effects model provides a significantly better fit. This finding implies that unobserved firm specific characteristics significantly influence disclosure behavior across the sample. To further verify the model selection, the Hausman test was conducted to compare the fixed effects model and the random effects model. The Hausman test produced a probability value of 0.0000, confirming that the fixed effects model is statistically more appropriate for the dataset. These results suggest that company specific heterogeneity plays an important role in explaining variations in carbon emission disclosure. Consequently, the regression analysis adopts the fixed effects model with robust standard errors to address potential heteroskedasticity across firms. The results of the panel regression estimation are presented in Table 3.

Table 3. Panel Regression Results (Fixed Effects Model)

Variables	Coefficient	Std. Error	t-statistic	p-value
Constant	0.5120	0.0500	10.225	0.0001
Financial Performance (ROE)	-0.0170	0.0130	-1.258	0.2550
Environmental Performance (PROPER)	0.0720	0.0210	3.411	0.0143**
Firm Size	0.6840	0.1580	4.322	0.0050***
ROE × Firm Size	0.0590	0.0450	1.305	0.2396
PROPER × Firm Size	-0.0010	0.0280	-0.057	0.9558

Notes:
*** $p < 0.01$
** $p < 0.05$
• $p < 0.10$

The regression results indicate that environmental performance has a positive and statistically significant impact on carbon emission disclosure. The positive coefficient suggests that firms receiving higher environmental ratings tend to disclose more information regarding carbon emissions and environmental management. This result indicates that companies with stronger environmental performance are more willing to communicate their environmental commitments to stakeholders. In contrast, financial performance does not show a statistically significant relationship with carbon emission disclosure. The insignificant coefficient implies that profitability alone does not necessarily motivate firms to provide greater environmental transparency. Firm size demonstrates a positive and statistically significant relationship with carbon disclosure, indicating that larger firms tend to face stronger institutional and stakeholder pressures to disclose environmental information. Larger organizations also tend to possess greater financial and managerial resources that support sustainability reporting. The adjusted R squared indicates that a substantial proportion of the variation in carbon emission disclosure is explained by the variables included in the model. Overall, these findings emphasize the importance of environmental accountability and organizational scale in shaping corporate environmental transparency.

To further investigate the moderating role of firm size, interaction terms between firm size and the explanatory variables were incorporated into the regression model. The interaction between financial performance and firm size does not show a statistically significant effect, indicating that firm size does not significantly alter the relationship between profitability and carbon emission disclosure. Similarly, the interaction between environmental performance and firm size does not reach statistical significance in the regression model. Nevertheless, interaction effects can sometimes be better interpreted through graphical analysis rather than relying solely on coefficient values. Therefore, an interaction plot was generated to visualize the moderating role of firm size in the relationship between environmental performance and carbon disclosure. The graphical analysis presented in Figure 1 illustrates that firms with larger asset bases demonstrate a steeper positive relationship between environmental performance and disclosure practices. In contrast, smaller firms exhibit a weaker slope, suggesting that improvements in environmental performance are less

strongly translated into disclosure practices. This pattern indicates that organizational scale may enhance the capacity of firms to transform environmental achievements into transparent sustainability reporting.

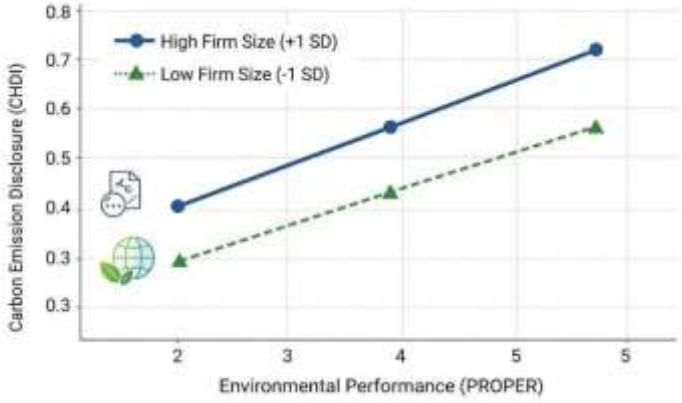

Figure 2. Interaction Effect of Firm Size on the Relationship Between Environmental Performance and Carbon Emission Disclosure

The interaction plot demonstrates that firms with larger organizational scale show a stronger positive relationship between environmental performance and carbon disclosure transparency. This finding suggests that large firms are more capable of converting environmental achievements into publicly communicated sustainability information.

Discussion

The empirical findings demonstrate that environmental performance significantly enhances corporate carbon emission disclosure, indicating that firms with stronger environmental management systems tend to communicate their environmental activities more transparently. This relationship can be interpreted through legitimacy theory, which suggests that organizations disclose environmental information to maintain alignment with societal expectations and regulatory norms. In contexts where environmental awareness is increasing, companies are under growing pressure to demonstrate responsible environmental conduct. Carbon disclosure therefore functions as a mechanism for signalling compliance with environmental standards and reinforcing organizational legitimacy. Firms that achieve higher environmental performance ratings are more likely to publicize such achievements to strengthen their reputation among stakeholders. This strategic communication helps reduce potential legitimacy gaps between corporate activities and societal expectations. Prior studies have reported similar relationships between environmental performance and sustainability disclosure in international contexts (Ali et al., 2024 and Khatri & Kjærland, 2023). The present findings therefore reinforce the argument that environmental performance provides the substantive basis that motivates firms to disclose environmental information.

The absence of a significant relationship between financial performance and carbon emission disclosure indicates that profitability alone does not necessarily drive environmental transparency. From the perspective of voluntary disclosure theory, firms disclose information when the perceived strategic benefits exceed the costs associated with reporting. Environmental disclosure, however, often requires additional monitoring systems, specialized reporting frameworks, and compliance mechanisms that may not immediately translate into financial returns. Consequently, firms may not perceive financial performance as a primary determinant of disclosure decisions. Instead, environmental reporting is frequently shaped by reputational considerations and institutional expectations rather than short-term profitability. These findings align with earlier research suggesting that financial indicators do not consistently predict sustainability disclosure behavior

(Mousa et al., 2022 and Warokka et al., 2025). Firms may prioritize legitimacy and stakeholder engagement over financial incentives when determining disclosure practices. Therefore, environmental transparency should be understood primarily as an institutional and reputational response rather than a direct outcome of financial success.

Firm size is found to have a significant positive relationship with carbon emission disclosure, indicating that larger organizations tend to disclose more environmental information than smaller firms. Stakeholder theory provides a useful framework for understanding this relationship because larger firms interact with a wider range of stakeholders and operate under greater public scrutiny. Institutional investors, regulators, environmental organizations, and civil society groups often demand higher levels of transparency from large corporations. As a result, large firms tend to adopt more comprehensive sustainability reporting practices to maintain stakeholder trust and organizational credibility. In addition, larger firms generally possess greater financial and managerial resources that enable them to implement sophisticated environmental reporting systems. This finding is consistent with previous research identifying firm size as one of the most consistent predictors of sustainability disclosure (Adu, 2022 and Akhter et al., 2023). The results therefore suggest that organizational scale amplifies institutional pressures that encourage firms to adopt transparent environmental reporting practices. Larger firms are thus more capable of translating sustainability commitments into formal disclosure mechanisms.

When viewed within a broader global context, the findings contribute to the growing literature on environmental disclosure in emerging economies. Studies conducted in developed economies often show that environmental disclosure is strongly shaped by regulatory enforcement and mature sustainability reporting frameworks. In contrast, firms operating in developing and emerging markets may face more heterogeneous institutional environments and varying levels of environmental governance. Within such contexts, environmental performance becomes an important signal that firms use to demonstrate responsibility and gain legitimacy in both domestic and international markets. Carbon disclosure can therefore serve as a strategic mechanism through which firms in emerging economies strengthen their credibility among global stakeholders. This dynamic has been increasingly observed in sustainability reporting research across developing markets (Du Toit, 2024 and Kvasničková Stanislavská et al., 2023). The present study contributes to this literature by showing that environmental accountability remains a critical driver of disclosure even in institutional contexts where regulatory enforcement may be evolving. These findings highlight the importance of environmental governance in shaping corporate transparency across different economic systems.

From a theoretical perspective, the study contributes to the integration of legitimacy theory, stakeholder theory, and voluntary disclosure theory in explaining corporate carbon disclosure behavior. The results demonstrate that environmental disclosure cannot be explained solely by financial incentives but instead emerges from the interaction between environmental accountability and institutional pressures. Legitimacy theory explains why firms seek to align their environmental reporting with societal expectations, while stakeholder theory highlights the role of external pressure from investors and regulators. Voluntary disclosure theory further clarifies how firms strategically communicate information to enhance credibility and reduce information asymmetry. Together, these theoretical perspectives provide a more comprehensive explanation of why firms disclose carbon emission information. In practical terms, the findings suggest that policymakers should strengthen environmental reporting frameworks to encourage greater corporate transparency. Regulators can also promote standardized carbon disclosure guidelines that reduce reporting uncertainty and improve comparability across firms. For corporate managers, the results emphasize the importance of integrating environmental performance with transparent communication strategies. Strengthening environmental management systems and sustainability

reporting practices can therefore help firms build long-term legitimacy and maintain strong relationships with stakeholders.

Implication

The findings of this study provide several theoretical and practical implications for the literature on environmental disclosure and corporate sustainability. From a theoretical perspective, the results strengthen the explanatory power of legitimacy theory and stakeholder theory in understanding corporate carbon disclosure behavior. The evidence suggests that firms disclose environmental information primarily to maintain legitimacy and respond to stakeholder expectations rather than to signal financial strength. This finding contributes to the growing body of research indicating that environmental transparency is driven more by institutional pressure and environmental accountability than by profitability considerations. In addition, the results highlight the important role of organizational scale in shaping disclosure practices, suggesting that larger firms are more responsive to external pressures related to environmental transparency. From a managerial perspective, the study indicates that companies seeking to strengthen their environmental credibility should integrate environmental performance improvements with transparent reporting practices. Managers should recognize that disclosure serves not only as a compliance mechanism but also as a strategic communication tool for building stakeholder trust and reputational capital. From a policy standpoint, regulators may use these insights to design stronger environmental reporting frameworks that encourage firms to disclose carbon emission information more consistently. Strengthening reporting standards and monitoring mechanisms may therefore enhance corporate environmental transparency and contribute to broader sustainability objectives.

Limitations

Despite its contributions, this study is subject to several limitations that should be acknowledged when interpreting the findings. First, the analysis focuses on a specific sample of firms within a particular institutional context, which may limit the generalizability of the results to other countries or regulatory environments. Environmental disclosure practices may differ substantially across institutional settings depending on the strength of environmental regulations and stakeholder pressures. Second, the study relies on a particular measure of carbon emission disclosure based on publicly available reports, which may not fully capture all dimensions of corporate environmental transparency. Some firms may engage in environmental practices that are not formally disclosed in sustainability reports, potentially leading to measurement limitations. Third, although the panel regression approach controls for firm-specific heterogeneity, the study may still be subject to unobserved factors that influence both environmental performance and disclosure decisions. Variables such as corporate governance quality, board environmental expertise, or sustainability strategy could further shape disclosure behavior but were not included in the present model. In addition, the moderating effect of firm size was explored within a single analytical framework, which may not capture more complex interaction patterns between organizational characteristics and environmental accountability. These limitations suggest that caution should be exercised when interpreting the causal relationships identified in the study. Future research may address these limitations by incorporating additional variables and broader datasets to strengthen empirical robustness.

Suggestions

Building on the limitations identified above, several directions for future research can be proposed to advance the understanding of corporate carbon disclosure practices. Future studies could expand the scope of analysis by incorporating cross-country comparisons to examine how institutional differences influence environmental disclosure behavior. Such comparative analyses would help identify whether the drivers of carbon disclosure differ between developed and emerging

economies. Researchers may also consider incorporating additional governance-related variables, such as board independence, environmental committees, or sustainability expertise, to better capture internal organizational factors influencing disclosure practices. In addition, future research could explore alternative measures of environmental performance and disclosure, including carbon intensity metrics or third-party sustainability ratings. The use of more advanced econometric techniques, such as dynamic panel models or endogeneity control methods, may further improve the robustness of empirical findings. Another promising direction involves examining the role of regulatory reforms or carbon reporting standards in shaping corporate disclosure behavior over time. Longitudinal studies could provide deeper insights into how firms adjust their environmental reporting strategies in response to evolving institutional pressures. Finally, integrating qualitative approaches such as case studies or interviews with sustainability managers could enrich the understanding of organizational motivations behind carbon disclosure decisions. These avenues of research may contribute to a more comprehensive understanding of how firms integrate environmental accountability with corporate transparency in the transition toward sustainable business practices.

CONCLUSION

This study examines the influence of financial performance, environmental performance, and firm size on corporate carbon emission disclosure using a panel data approach. The findings show that environmental performance plays a significant role in explaining corporate transparency related to carbon emissions, while firms with stronger environmental performance tend to disclose more comprehensive information regarding their environmental impact. In contrast, financial performance does not show a significant relationship with carbon emission disclosure, indicating that profitability alone does not necessarily encourage firms to improve environmental transparency. The results also reveal that firm size significantly affects disclosure behavior, as larger firms tend to provide more extensive environmental information due to greater stakeholder scrutiny and institutional pressure. These findings confirm that environmental disclosure is shaped more by environmental responsibility and stakeholder expectations than by financial capability alone, highlighting the importance of environmental governance in promoting transparent sustainability reporting. From a broader perspective, this study contributes to the understanding of corporate environmental disclosure by integrating legitimacy theory, stakeholder theory, and voluntary disclosure theory. The results show that firms use carbon disclosure as a strategic mechanism to maintain legitimacy, strengthen stakeholder relationships, and reinforce organizational credibility in increasingly environmentally conscious markets. The study also offers practical implications for policymakers, regulators, and corporate managers by showing that stronger reporting frameworks, environmental management systems, and transparent communication practices can enhance the reliability of environmental information, support long term legitimacy, and strengthen stakeholder trust.

AUTHOR CONTRIBUTIONS STATEMENT

Gilang Surya Pratama and Rilla Gantino jointly contributed to the development and completion of this study. Gilang Surya Pratama was primarily responsible for conceptualizing the research framework, designing the research methodology, collecting and organizing the dataset, and conducting the empirical analysis. Gilang Surya Pratama also led the preparation of the initial manuscript draft, including the development of the introduction, results, and discussion sections. Rilla Gantino contributed to refining the research design, strengthening the theoretical framework, and reviewing the empirical findings to ensure their consistency with the existing literature. Rilla

Gantino also played an important role in critically revising the manuscript, improving the academic argumentation, and ensuring that the article met the standards required for international scholarly publication.

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