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Assessing of ESG Scores on Carbon Performance: Moderating Role of Board Independence

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Abstract: This study is motivated by the rising levels of carbon emissions and the increasing importance of ESG practices as mechanisms for enhancing corporate environmental performance. It investigates whether board independence moderates the relationship between ESG scores and carbon emission performance, using panel data from 81 companies listed on the Indonesia Stock Exchange between 2022 and 2024 and secondary data are obtained from the Refinitiv Eikon database. The study applies moderated regression analysis, estimated using EViews. The results indicate that ESG scores have a significant positive impact on carbon emission performance, suggesting that higher ESG scores are associated with improved carbon outcomes. In contrast, board independence has a negative effect. Additionally, board independence does not significantly moderate the relationship between ESG and carbon emission performance, implying that it is an inadequate governance mechanism for strengthening the impact of ESG practices.
Keywords: ESG; Carbon Emissions Performance; Board Independence.

Abstrak: Penelitian ini dilatarbelakangi oleh peningkatan emisi karbon dan semakin pentingnya praktik Environmental, Social, and Governance (ESG) sebagai instrumen untuk meningkatkan kinerja lingkungan perusahaan. Studi ini menguji apakah independensi dewan memoderasi hubungan antara skor ESG dan kinerja emisi karbon dengan menggunakan data panel 81 perusahaan yang tercatat di BEI pada periode 2022–2024 dan memiliki skor ESG yang dilaporkan dalam basis data Refinitiv Eikon. Studi ini menggunakan teknik purposive sampling dan data sekunder yang diperoleh dari basis data Refinitiv Eikon. Penelitian ini menggunakan moderated regression analysis yang diestimasi dengan EViews. Hasil studi menunjukkan skor ESG berpengaruh positif terhadap kinerja emisi karbon, yang mengindikasikan bahwa skor ESG yang lebih tinggi berkaitan dengan kinerja emisi karbon yang lebih baik. Sebaliknya, independensi dewan memberikan pengaruh negatif signifikan. Lebih lanjut, independensi dewan tidak memoderasi hubungan antara ESG dan kinerja emisi karbon, yang menunjukkan bahwa mekanisme tata kelola ini tidak memadai untuk memperkuat dampak ESG.
Keywords: ESG; Kinerja Emisi Karbon; Independensi Dewan.

INTRODUCTION

Climate change is one of the most pressing problems facing the contemporary world. As it significantly affects the robustness of social institutions and the stability of the world economy, the ongoing environmental disaster presents grave threats to natural ecosystems (Jarboui et al., 2025). Since large corporations are responsible for a disproportionate share of the world's greenhouse gas emissions, their role in this problem is under more scrutiny (Jarboui et al., 2025).

Elago et al. (2025) assert that greenhouse gases (GHGs) are atmospheric components that trap heat, which has a profound impact on the Earth's climate system. Global emissions have been on an alarming upward trend, as seen in Figure 1, and this trend is only going to become worse. According to Statista (2025a) the quantity of carbon dioxide emissions into the atmosphere has surged by almost 60per cent between 1940 and 2024. Industrial activities

Jurnal Akuntansi
e-JA
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and fossil fuel combustion accounted for an amazing 37.010 billion metric tonnes ($GtCO_2$) of carbon dioxide emissions in 2023 (Statista, 2025b).

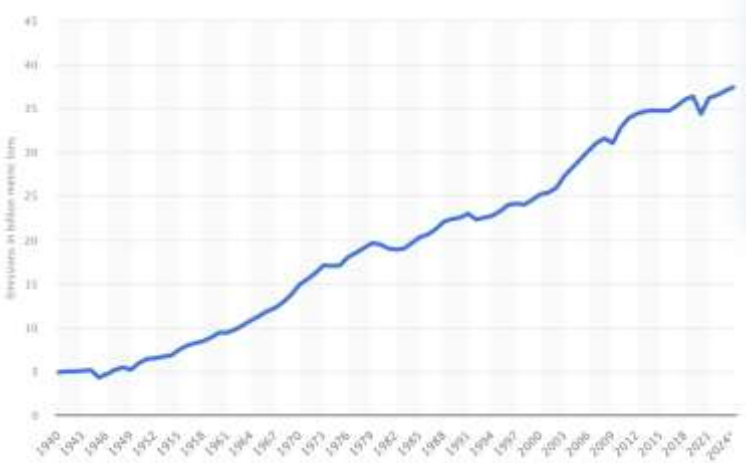

Figure 1. Global annual carbon dioxide (CO_2) emissions from 1940 to 2024 (measured in billion metric tonnes)
Source: (Statista, 2025a)

With 729 million metric tons of CO_2 emissions in 2022, Indonesia ranked higher than any Southeast Asian country and was in the top five for the Asia-Pacific region (Statista, 2025b). The industrial sector accounts for a significant amount of the GHG emissions and production in Indonesia. The production of chemicals, steel, and cement, in addition to other industrial operations, and the processing of fossil fuels to generate electricity, all contribute significantly to the nation's carbon footprint. Emissions from fuel combustion and energy-intensive industrial processes are mostly caused by the textile and agricultural sectors (IEC, 2024).

Air pollution, increased rates of respiratory and cardiovascular illnesses, and other public health problems caused by greenhouse gas emissions affect populations and regions much beyond the borders of any one country (Manisalidis et al., 2020). In addition to hastening the process of global warming and having these apparent impacts on human health, greenhouse gases also intensify the greenhouse effect. Consequently, storms, heat waves, floods, and droughts become more frequent and more intense as a result of this. They also increase the likelihood and severity of wildfires, which causes challenges for agriculture via altered precipitation patterns and decreased agricultural yields (Chen et al., 2021). The severity and global scale of these repercussions have elevated climate change and sustainable development to the forefront of international policy discourse, thereby influencing the formulation of frameworks worldwide.

These environmental challenges have compelled numerous governments to prioritize sustainable development and transition to a low-carbon economy. In pursuit of these objectives, it is essential to substantially reduce and sustain low levels of carbon emissions. Major corporations are increasingly facing pressure regarding climate change to enhance transparency and accountability concerning their environmental impacts and their contribution to global emissions (Jarboui et al., 2025). According to Koseoglu et al.(2024), Carbon emission performance (CEP) refers to a company's commitment to effectively reduce environmental emissions within its production and operational processes. Practical CEP evaluation may help businesses conserve energy, reduce emissions, and promote sustainable development (Zhou et al., 2022).

Jurnal Akuntansi
e-JA
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Firms that demonstrate strong performance in reducing carbon emissions are recognised as leaders in environmental management, aligning their practices with global sustainability objectives and increasingly stringent regulatory standards (Rana et al., 2025). This achievement is typically underpinned by comprehensive carbon accounting systems, robust ESG performance, effective internal governance structures, supportive regulatory frameworks, technological innovations in energy efficiency and cleaner production, and targeted corporate strategies that integrate climate considerations into core business models (Li et al., 2024; Masud et al., 2025; Rana et al., 2025). As a result, companies with superior carbon emission performance tend to enjoy higher market valuations and enhanced access to capital, as investors and lenders increasingly favour firms with lower carbon footprints and lower transition risk (Benkraiem et al., 2022).

Due to a higher priority on corporate responsibility, companies are under more scrutiny to reveal their greenhouse gas emissions (Jarboui et al., 2025). As a consequence, the Indonesian government has established a comprehensive regulatory framework on sustainability reporting and carbon management. Peraturan Otoritas Jasa Keuangan No. 51/POJK.03/2017 mandates the publication of sustainability reports detailing the economic, social, and environmental performance of listed firms, issuers, and financial institutions. This requirement is further supported by technical guidelines that govern the content and format of these reports.

At the national policy level, Keputusan Presiden No. 61 Tahun 2011, concerning the Rencana Aksi Nasional – Gas Rumah Kaca (RAN-GRK), establishes sector specific targets for emission reductions and mandates the implementation of monitoring and reporting mechanisms, thereby emphasizing the need for transparent carbon disclosure. Recently, Keputusan Presiden No. 98 Tahun 2021 and POJK No. 14 Tahun 2023 established carbon pricing mechanisms and market-based processes, thereby encouraging enterprises to quantify, regulate, and publicly disclose their carbon emissions.

Within this regulatory and societal framework, ESG initiatives are becoming increasingly important in affecting business behavior in Indonesia. Nowadays, the majority consider ESG performance to be a strategic asset. Research has revealed that companies with higher ESG scores perform more effectively, have more financing options, and are less likely to experience stock market crashes. (Deng et al., 2023; Koseoglu et al., 2024).

To support the increasing significance of ESG factors, several independent organizations have established standardized ESG rating systems. Refinitiv, Sustainalytics, FTSE, MSCI, Inrate, and Bloomberg are some of the most well-known organizations that offer these kinds of measurements. Empirical evidence indicates that these ESG ratings significantly affect investment decisions, especially among institutional investors controlling huge portfolios (Gibson et al., 2022).

Study by Koseoglu et al. (2024), Cong et al. (2022) and Yang & Hei (2024) have highlighted the increasing significance of ESG practices in enhancing environmental performance. Corporations often demonstrate their environmental commitment by improving their carbon emissions performance through the systematic integration of ESG principles into their operations. According to Firmino & Peixoto (2025), companies operating in sectors with robust carbon reduction strategies and higher ESG ratings tend to attract a greater number of environmentally conscious investors and consumers.

Nevertheless, some research argues that carbon emissions are not constantly affected by ESG practices. According to Luo & Tang (2023), improvements in observable environmental outcomes, like lower carbon emissions, are not always reflected in an increase in ESG disclosures. Similarly, Treepongkaruna et al. (2024) found that businesses

Jurnal Akuntansi
e-JA
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with higher ESG scores may not always have higher CEP. Since their environmental responsibility is currently widely accepted by the public, these companies may not be sufficiently inspired to improve their environmental efforts.

The characteristics of a company's board, such as board independence (BI), are closely associated with carbon performance. Kim et al. (2023) have observed that BI are generally associated with better environmental outcomes due to their increased likelihood of prioritizing long-term sustainability over short-term earnings. Consistent with agency theory, BI are more adept at overseeing management and resolving agency issues. Jamil & Wahyuni (2025) contend that a company's environmental performance can be substantially improved by boards that are dedicated to preserving effective ESG principles. Nevertheless, other research suggests that BI does not always result in a reduction in CEP. This implies that, despite the fact that BI may concentrate on carbon management, it does not inherently result in significant reductions in emissions (Oyewo, 2023).

This paper aims to analyze how BI moderates the relationship between ESG scores and CEP, using Indonesia as a case study. Indonesia is a developing country that is part of the ASEAN framework. Since there is a lack of existing empirical data on the moderating effect of board independence in emerging market economies, this research steps in to address that knowledge gap. As a significant and measurable environmental outcome, CEP is also included in this study under the ESG paradigm. By linking ESG performance to measurable environmental outcomes, rather than solely focusing on ESG disclosures or ratings, this study provides a more comprehensive assessment of the effectiveness of ESG initiatives compared to previous research.

THEORETICAL REVIEW

Stakeholder theory explain the company's main goal is to generate value for all its stakeholders, which encompass customers, suppliers, employees, communities, and shareholders (Hapsari et al., 2025). In this regard, firms that exhibit higher levels of stakeholder engagement are more inclined to adopt comprehensive environmental policies and practices, which in turn contribute to improved sustainable performance (Shang, 2025). Stakeholder pressures thus function as critical drivers for the implementation of low-carbon operational practices. Moreover, strong and collaborative relationships with stakeholders enhance a firm's ability to navigate external challenges and strengthen its competitive position, thereby ultimately improving its carbon performance (Lopes de Sousa Jabbour et al., 2021).

Agency Theory explain a conflict of interest resulting from the separation of ownership and control is the source of the agency dilemma. In their capacity as agents, managers may prioritize their personal interests over those of the principals, a situation that could lead to adverse outcomes, particularly if they face information asymmetry or possess differing risk preferences (Khandelwal et al., 2023). Effective corporate governance can mitigate the impact of agency conflicts by reducing agency costs, such as monitoring, bonding, and residual losses. According to agency theory, governance mechanisms such as board oversight, incentive systems, and transparency help align the interests of management with those of shareholders, thereby lowering agency costs and enhancing organizational performance (Barros et al., 2020).

Carbon emissions performance (CEP) refers to an organisation's efficiency in managing and reducing its GHG emissions and is widely recognised as a core indicator of environmental sustainability and corporate responsibility (Honma et al., 2023). In practice,

Jurnal Akuntansi
e-JA
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strong CEP reflects the effective implementation of carbon management strategies, such as energy-efficiency improvements, process optimization, the deployment of low-carbon technologies, and fuel switching, which are designed to mitigate emissions while simultaneously advancing broader sustainability and climate transition objectives (Koseoglu et al., 2024; Rana et al., 2025). Recent empirical research suggests that carbon emission performance (CEP) is influenced by a combination of internal and external factors, such as corporate governance frameworks, ESG practices, and broader macroeconomic conditions. (Narsa Goud, 2022; Oyewo, 2023). Furthermore, superior CEP is progressively linked to favorable economic outcomes. Evidence shows that firms with lower or more efficiently managed emissions typically achieve higher market valuations and better financial performance, indicating that investors reward credible progress toward a low-carbon business model (Benkraiem et al., 2022; Rahayu & Sanjaya, 2024). Overall, the extant literature positions CEP as an environmental indicator as well as a strategic and financial performance metric embedded within contemporary carbon accounting and sustainability management frameworks.

The Environmental, Social, and Governance (ESG) Score allows stakeholders to assess and contrast a company's overall dedication to social responsibility and environmental sustainability as a standardized benchmark (Elago et al., 2025). One of the most advanced and frequently implemented frameworks to encourage sustainability is ESG. The core ideas of corporate responsibility are encapsulated in the three pillars of governance (G), social responsibility (S), and environmental responsibility (E) (Baratta et al., 2023; Jamil & Wahyuni, 2025). The environmental dimension evaluates a company's impact on the environment, including carbon output, resource consumption, waste management, and conservation initiatives (Gravel, 2023). The social dimension addresses issues like labour practices, human rights, community engagement, and more general social justice concerns. It focusses on how a business manages its relationships with stakeholders (Baratta et al., 2023). The governance dimension focuses on the structures and processes that guide corporate leadership and oversight, including executive remuneration, audits, internal control systems, and the protection of shareholder rights, with a particular emphasis on decision-making, accountability, and transparency (Redor & Blomkvist, 2021).

Board independence (BI) is the inclusion of non-executive directors who are not engaged in daily management activities, enabling them to provide impartial oversight of management and reduce agency conflicts between executives and shareholders (Kijkasiwat et al., 2022). Independent directors strengthen the board's monitoring function by critically evaluating strategic decisions, risk-taking behaviour, and financial reporting practices, thereby constraining managerial opportunism and limiting the scope for actions that diverge from shareholders' interests (Kijkasiwat et al., 2022; Zaid et al., 2020). Through this enhanced monitoring role, BI serves as a key governance mechanism that facilitates the alignment of managerial incentives and decisions to maximize long-term shareholder value, particularly in contexts characterized by high information asymmetry and concentrated ownership structures (Zaid et al., 2020). Empirical evidence shows that independent directors foster more extensive CSR and ESG-related policies and disclosures, which both address stakeholder expectations and mitigate long-term non-financial risks, thereby reinforcing the alignment between shareholders' long-run interests and broader stakeholder concerns (Celentano et al., 2020; Endrikat et al., 2021; Zaid et al., 2020).

ESG Score and Carbon Emission. The stakeholder theory emphasizes the crucial role of interactions between an organization and its various stakeholder groups. It posits that value creation arises from voluntary collaboration across these groups, enabling the

Jurnal Akuntansi
e-JA
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provision of goods and services beyond the capacity of any single actor (Mutebi et al., 2025). This conceptual framework serves as a strategic tool for managers in addressing and balancing the varied expectations and concerns of stakeholders (Moriarty, 2024)

From this perspective, ESG has become a widely adopted framework for implementing sustainability, where ESG capture the key aspects of sustainable development and corporate responsibility (Baratta et al., 2023). ESG performance can be considered an approach for businesses to demonstrate accountability and legitimacy in society, in accordance with stakeholder theory, which posits that an organization's success depends on its ability to meet the expectations of various stakeholders (Jamil & Wahyuni, 2025).

ESG scores serve as essential indicators of how effectively firms integrate ESG aspect into their strategies and operations. ESG score has increasingly used as decision-relevant signals for investors, regulators, and other stakeholders. Empirical evidence shows that higher ESG performance is typically associated with lower carbon emissions or reduced carbon emission intensity, suggesting that firms with superior ESG scores are more proactive in carbon management and climate-related risk mitigation (Alandejani & Al-Shaer, 2023; Li & Xu, 2024; Xie et al., 2024). Li and Xu (2024) document that higher ESG ratings significantly curb CEP, while Xie et al. (2024) show that ESG performance reduces carbon emission intensity by encouraging firms to invest in environmental governance, improve profitability, and stimulate green technological innovation. Similarly, Koseoglu et al. (2024) find that ESG predict better CEP in multinational companies, reinforcing the idea that ESG performance is closely intertwined with decarbonisation efforts. At a broader level, studies also indicate that ESG practices and sustainability-related scores enhance CEP by shaping firms' responses to macroeconomic and regulatory pressures (Alandejani & Al-Shaer, 2023).

From stakeholders theory perspective, firms recognise that lower carbon emissions can strengthen their legitimacy and reputation, build trust among environmentally conscious consumers, and generate competitive advantage through revenue growth and cost reductions (Cao & Rees, 2020). Capital providers, such as shareholders and debtholders, increasingly reward firms that exhibit superior carbon performance through lower perceived risk, better access to finance, and potentially lower cost of capital while penalising carbon-intensive firms through higher financing costs and valuation discounts (Albarrak et al., 2019; Treepongkaruna et al., 2024). Conversely, poor CEP exposes firms to reputational damage, activist pressure, boycotts, and regulatory sanctions, all of which can erode firm value and stakeholder trust. In this context, higher ESG scores encourage firms to realign their strategies, invest in cleaner technologies, and strengthen climate-related risk management, thereby improving their carbon performance and sustaining stakeholder support. Accordingly, building on stakeholder theory and the growing empirical evidence that stronger ESG performance is associated with lower emissions and enhanced carbon outcomes, it can be hypothesized below:

H1: The ESG score has a significant effect on carbon emission performance.

Board Independence and Carbon Emission Performance. BI is widely regarded as a key element of corporate governance, enhancing decision-making quality and strengthening management oversight (Kijkasiwat et al., 2022; Zaid et al., 2020). According to agency theory, a higher proportion of BI is expected to reduce conflicts of interest between managers and shareholders, particularly in areas involving long-term risks, such as climate change and environmental exposure. This is achieved by curbing managerial

Jurnal Akuntansi
e-JA
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opportunism and encouraging decisions that protect the long-term value of the firm (Celentano et al., 2020; Zaid et al., 2020). Empirical evidence from Nasih et al. (2020) suggests that BI significantly enhances the disclosure of carbon emissions in Indonesian publicly listed companies, indicating that boards with greater independence are associated with improved transparency in carbon-related reporting. Studies focused specifically on carbon reporting further show that board independence is positively correlated with carbon emission disclosure, reflecting stronger accountability for environmental externalities (Mansour et al., 2025; Saraswati et al., 2021).

More recent research extends this relationship from disclosure to actual environmental and carbon outcomes. Narsa Goud (2022) provides evidence that BI is positively associated with CEP, suggesting that BI can drive the implementation of more effective carbon management practices, rather than merely influencing disclosure policies. Similarly, Kim et al. (2023) find that BI is linked to lower carbon emissions and weakens the positive association between high emissions and financial performance, suggesting that BI are more inclined to balance financial objectives with environmental considerations and to resist short-term profit motives that would otherwise tolerate high emissions. Complementing agency theory, stakeholders theory explain that BI mitigates the impact of managerial and shareholder pressures, allowing BI to be more responsive to social and environmental issues (Celentano et al., 2020). This heightened responsiveness enables more efficient oversight of environmental decisions, which is expected to result in better CEP (Moussa et al., 2019). Collectively, these findings are consistent with both agency and stakeholder theory, which explain that BI enhance monitoring and reduce agency costs, while simultaneously responding to stakeholder expectations for responsible environmental behaviour and credible climate action. Therefore, it can be hypothesized below :

H2: Board independence has a significant effect on carbon emission performance.

The Moderating Role of Board Independence in the Relationship between ESG Score and Carbon Emission Performance. BI is expected to play a crucial moderating role in the relationship between ESG scores CEP. Previous empirical research indicates that higher ESG scores are generally associated with improved CEP, as companies with stronger ESG practices tend to adopt cleaner technologies, invest in green innovation, and implement more robust environmental management systems, thereby reducing their GHG emissions (Firmino & Peixoto, 2025; Qian & Liu, 2024; Xie et al., 2024). In this context, ESG performance acts as a key driver of decarbonisation. However, the effectiveness of ESG initiatives in improving carbon emission performance may, in part, depend on the quality of corporate governance, particularly the extent of board independence.

From the perspective of agency theory, conflicts of interest between shareholders (principals) and managers (agents) can undermine the commitment to long-term sustainability, particularly when investments in emission reductions involve substantial short-term costs and uncertain returns (Benkraiem et al., 2022). In this context, BI play a crucial role in aligning the interests of management with those of shareholders. Through effective oversight and the implementation of robust ESG strategies, independent boards can enhance the effectiveness of ESG practices in reducing carbon emissions (Alkurdi et al., 2024; Ding et al., 2024; Ihbal et al., 2024).

Additionally, stakeholder theory highlights the importance of considering the interests of all stakeholders (Hapsari et al., 2025). BI are better positioned to balance these diverse interests, including those advocating for environmental sustainability. By promoting

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
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transparency and accountability in ESG practices, BI are able to strengthen a company's reputation and build greater trust among stakeholders, both of which contribute to improved CEP (Elsayih et al., 2021; Kim et al., 2023). Therefore, BI can strengthen the positive impact of ESG scores on CEP. Therefore, it can be hypothesized below:

H3: Board independence strengthens the effect of ESG score on carbon emission performance.

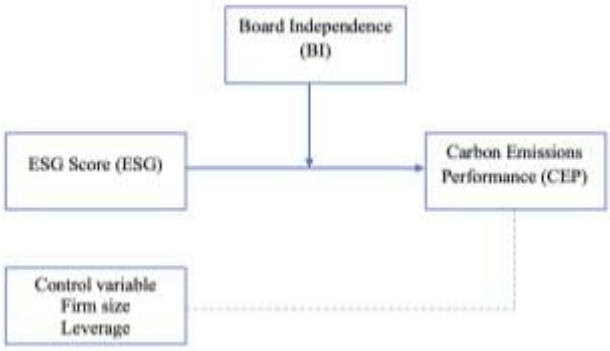

Figure 2. Research Model

METHODS

Sample selection. This study employ secondary data obtained from the Refinitiv Eikon database to conduct quantitative research. The population comprises companies listed on the Indonesia Stock Exchange between 2022 and 2024. The sample is drawn from companies with available ESG Score data in the Refinitiv Eikon database for the same period, with the final sample consisting of 81 companies.

This research examines three variables: the independent variable, identified as the ESG score; the dependent variable, represented by carbon emissions performance; and the moderating variable, defined as board independence. This study utilizes ESG as an independent variable since it is a set of measurable components that assess the ethical and environmental impacts of corporate actions (Li & Xu, 2024). (Alandejani & Al-Shaer, 2023; Koseoglu et al., 2024; Li & Xu, 2024; Xie et al., 2024) all support the premise that companies with higher ESG scores are more inclined to take action to enhance their environmental performance and increase their carbon footprint reduction efforts. Thus, ESG may be used as a predictor of carbon emissions performance, the dependent variable.

The study's control variables were the companies' sizes and levels of leverage (Jamil & Wahyuni, 2025). Large corporations often have more financial resources, more extensive management systems, and more human and material manpower (Ihar Dzeraviaha, 2023). These advantages enable them to implement more effective sustainability practices, such as improving ESG scores and reducing carbon emissions (Sun et al., 2025). According to Akhtar et al. (2025), larger corporations are increasingly being urged by regulators and analysts to implement environmental policies, a shift that may result in enhanced ESG performance. Therefore, by accounting for the influence of company size, a more comprehensive understanding of the relationship between ESG performance and carbon emissions may be achieved.

Leverage is a measure of a company's financial health and its ability to meet its debt obligations. Dang et al. (2025) suggested that organizations with higher levels of debt may

Jurnal Akuntansi
e-JA
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encounter difficulties in implementing sustainable practices, such as enhancing their ESG ratings and reducing carbon emissions, due to the associated costs and the limited availability of long-term financing. Therefore, incorporating leverage into the analysis helps to clarify the potential financial constraints affecting the relationship between ESG performance and carbon emissions.The details of these variables are presented in the **Table 1**.

Table 1. Operational Variables

Variables	Variable definition	Indicator	Scale
ESG Score	The metrics that assess a company's vulnerability to long-term environmental, social, and governance risks (Treepongkaruna et al., 2024)	ESG Score (Refinitiv Eikon Database)	Ratio
Carbon Performance	This score assesses a company's dedication and effectiveness in reducing environmental emissions within its production and operational processes (Koseoglu et al., 2024)	Carbon Emission score (Refinitiv Eikon Database)	Ratio
Independent Board	The proportion of outside directors on the board (Kim et al., 2023)	Percentage of independent board members (Refinitiv Eikon Database)	Ratio
Firm size	A critical factor that influencing various aspects of business performance, economic policy, and strategic decisions (Dzeraviaha, 2023b).	Logarithm natural from total assets (Refinitiv Eikon Database)	Ratio
Leverage	The debt-to-asset ratio is a financial metric that indicates the proportion of a company's assets that are financed by debt (Hertz et al., 2024)	Total debt to total assets (Refinitiv Eikon Database)	Ratio

Sourced : Previous research, Refinitiv Database

The statistical analysis was performed using panel data regression, which is appropriate for datasets containing both cross-sectional and time-series elements. Prior to conducting the statistical tests, classical assumption tests, including those for multicollinearity and heteroscedasticity, were undertaken. To determine the most appropriate model, three options were considered: the Common Effect Model (CEM), the Fixed Effect Model (FEM), and the Random Effect Model (REM) (Ghozali & Ratmono, 2020).

After selecting the optimal estimation method, classical assumption tests were conducted. A multicollinearity test was performed by assessing the correlation coefficients between variables, where values below 0.900 indicated no multicollinearity. A heteroscedasticity test was also carried out by analyzing the probability values of each variable, with values exceeding 0.050 signifying no heteroscedasticity. Furthermore, panel data regression was deemed suitable for testing both simultaneous and partial hypotheses (Ghozali & Ratmono, 2020).

The panel data regression model consists of two structures used to analyze the research model. The first structure examines the effect of ESG score and board independence on carbon emissions performance. The second structure discusses the moderating effect of

Jurnal Akuntansi
e-JA
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board independence on the relationship between ESG score and carbon emissions performance. The regression equations for Structure I and Structure II are formulated as follows:

Structure I :

$$CARBONi,t = \alpha + \beta_1 ESGi,t + \beta_2 BIi,t + \beta_3 SIZE\, i,t + \beta_4 LEVi,t + \varepsilon i,t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Structure II :

$$CARBONi,t = \alpha + \beta_1 ESGi,t + \beta_2 (ESGi,t \times BIi,t) + \beta_3 SIZEi,t + \beta_4 LEVERAGEi,t + \varepsilon i,t \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(2)$$

In this specification, $ESGi,t$ represents the firm's aggregate ESG score, $ESGi,t \times BIi,t$ denotes the interaction term between ESG performance and board independence, capturing the moderating effect. *SIZE* represents firms and LEV represents leverage. The constant value is symbolised by α, whereas β_1, β_2 β_3,β_4 denote the regression coefficients of the respective independent variables. The term ε accounts for the error component in the equation.

RESULTS

Descriptive Statistic describes data from the maximum value, minimum value, mean value, and standard deviation for the emission reduction score, ESG score, board independence, firm size and leverage.

Table 2. Desriptive Statistic

Variable	Mean	Maximum	Minimum	Std. Dev.
Carbon Emission Performance	51.088	99.090	0.000	24.705
ESG Score	51.529	88.940	12.380	18.608
Board Independence	0.472	0.833	0.157	12.717
Firm Size	31.363	35.430	26.220	24.007
Leverage	0.550	1.470	0.100	0.242

Source : Data Processed, 2025

Table 2 shows, the Carbon Emission performance, with a mean score of 51.090, indicates a moderate level of commitment by companies to reducing carbon emissions in their operations. However, the minimum score of 0 suggests that some companies either lack initiatives or fail to report their efforts, while the maximum score of 99.090 reflects organizations with exemplary environmental practices. The standard deviation of 24.710 highlights significant variability in emission reduction efforts across firms, suggesting that while some companies are at the forefront of environmental sustainability, others are significantly lagging.

The ESG Score in **Table 2** has a mean of 51.530, indicating a moderate exposure a company's vulnerability to long-term environmental, social, and governance risks. The minimum value of 12.380 suggests that some companies are highly vulnerable due to weaknesses in their ESG practices, possibly facing increased regulatory, reputational, and financial risks. In contrast, the maximum value of 88.940 reflects firms that have implemented effective strategies to mitigate ESG risks, enhancing their resilience to

Jurnal Akuntansi
e-JA
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environmental and social challenges. The standard deviation of 18.610 reveals significant variability in how companies manage these risks, indicating that while some companies are excelling in ESG management, others are underperforming.

Table 2 shows that board independence has a mean score of 0.472, indicating companies maintain a moderate level of independence within their boards. The minimum value of 0.157 highlights companies with boards that are highly influenced by internal stakeholders, while the maximum score of 0.833 indicates firms with highly independent boards.

Firm Size, with a mean of 31.360 as shown in **Table 2**, indicates that most companies in the sample are of a relatively large size. Then, Leverage ratio with a mean of 0.550, reflects a balanced average debt-to-equity ratio among firms. The minimum value of 0.100 indicates companies with very low debt levels, possibly operating with conservative financial strategies, while the maximum of 1.470 suggests that some firms rely heavily on debt to finance their operations.

Panel data model selection

Table 3. Section Data Panel Model

Structure	Test	Probability Result	Selected Model
Structure I	Chow Test	0.000	FEM
	Hausman Test	0.165	REM
	LM Test	0.000	REM
Structure II	Chow Test	0.000	FEM
	Hausman Test	0.190	REM
	LM Test	0.000	REM

Sourced : Data Processed, 2025

Table 3, both structures follow a thorough model selection process, with the Random Effect model emerging as the preferred option due to consistent results from the Chow, Hausman and Lagrange Multiplier tests.

Classical assumption tests, including the multicollinearity and heteroscedasticity tests, were conducted following the selection of the research model using the random effects model. The pairwise correlation method revealed that the correlation coefficient between the independent variables was below 0.080, suggesting that the research model is not affected by multicollinearity. Additionally, the Glejser heteroscedasticity test was performed, yielding a probability value greater than 0.050, indicating that the model is free from heteroscedasticity.

The Hypothesis Test was conducted to examine whether the ESG score and board independence have an effect on carbon emissions and whether the board independence moderates the relationship between the ESG score and carbon emissions performance.

Table 4. F-test and coefficient determination

Description	Structure I	Structure II
N	283	283
Adjusted R-squared	0.455	0.459
Prob (F-statistic)	0.000	0.000

Source : Data processed, 2025

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
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Table 4 shows demonstrates that there is a strong simultaneous impact of Structures I and II, with a probability value of 0.000. Structure I's ESG Score and Board Independence account for about 45.550 percent of the variance in carbon emission performance, according to the modified R-squared value of 0.455. The modified R-squared rises to 0.459, indicating a minor improvement of 0.360 percent, once Board Independence is included as a moderating variable in Structure II. The results show that the moderating impact of board independence on the association between ESG performance and carbon emission outcomes is still rather limited.

Table 5. t-Test

Variable	Coefficient	t-Statistic	Probability	Remark
Structure I				
ESG → CEP	0.987	12.281	0.000	H_1 Accepted
BI → CEP	-18.574	-2.627	0.009	H_2 Accepted
LEV → CEP	0.489	0.083	0.933	
SIZE → CEP	0.361	0.324	0.746	
Structure II				
ESG → CEP	0.663	3.549	0.000	
BI → CEP	-52.211	-2.745	0.006	
ESG*IB → CEP	0.659	1.915	0.056	H_3 Rejected
LEV → CEP	-1.177	-0.198	0.842	
SIZE → CEP	0.365	0.3269	0.744	

Source: Data processed, 2025

Table 5, Structure I, demonstrates that ESG exhibits a significance level of 0.000 and a coefficient of 0.987, indicating a positive impact on carbon emission performance (CEP). This finding supports H1, leading to its acceptance. Board Independence (BI) shows a significance value of 0.009 and a coefficient of -18.574, reflecting a significant negative influence on CEP, thereby confirming H2. Leverage (LEV) has a significance value of 0.933, suggesting no meaningful effect on CEP. Similarly, Firm Size (SIZE) reports a significance value of 0.746, implying that SIZE does not significantly affect CEP.

In Structure II, ESG retains a significance value of 0.000 and a coefficient of 0.663, reaffirming its positive influence on CEP. Board Independence exhibits a significance value of 0.006 and a coefficient of -52.211, indicating a significant negative impact on CEP. The interaction term (ESG*BI) presents a significance value of 0.056 and a coefficient of 0.659, suggesting a positive yet statistically insignificant moderating effect, leading to the rejection of H3. Leverage (LEV) again shows a significance value of 0.842, implying no significant impact on CEP, while SIZE remains insignificant with a significance value of 0.744.

DISCUSSION

Environmental, Social and Governance Score (ESG) on Carbon Emission Performance. Empirical research indicates a statistically significant and positive relationship between ESG ratings and carbon emission performance (CEP). With a probability value of 0.000 and a regression coefficient of 0.987, the results demonstrate a significant positive impact. This coefficient reveals a strong correlation between an organization's ability to manage and reduce its carbon emissions and the quality of its ESG practices, suggesting that a one-unit increase in ESG scores is associated with an approximate 0.988-unit improvement in CEP. In this context, organizations with higher ESG

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
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ratings are more likely to exhibit favorable CEP, while those with lower scores tend to perform poorly.

The results are in line with stakeholder theory, according to which companies may improve their performance and the value they create by methodically attending to the needs and wants of different stakeholder groups (Shang, 2025). By adopting ESG-oriented practices, businesses can enhance their credibility, reputation within the community, and stakeholder trust, while simultaneously contributing to environmental preservation through improved carbon emission management. Organizations that align with stakeholder expectations often experience superior financial performance, which may account for the positive correlation observed between ESG ratings and CEP (Saini et al., 2023). This relationship fosters improvements in CEP, driven by increased investments in carbon reduction initiatives, technological advancements, and pollution mitigation strategies (Cardillo & Basso, 2025).

However, this result contradicts the study of Tunçel et al. (2025), which fails to establish a causal relationship between ESG scores and CEP. This implies that ESG scores do not always result in reduced carbon emissions, yet they might reflect some sustainable initiatives. This result is further counter to the Treepongkaruna et al. (2024) study, which found that some companies with high ESG ratings do not have decreased carbon emissions. This implies that these companies may be engaging in greenwashing to obtain favorable press rather than being truly dedicated to lowering their carbon impact.

Board Independence on Carbon Emission Performance. The results reveal that BI has a negative and significant effect on CEP. The values of the regression coefficients in the main model are -18.570 and -52.210 in the moderation model. These coefficients indicate that a 0.100 increase in BI is associated with a decrease of approximately 1.857 points in CEP in the main model. The results indicate that firms with a higher proportion of BI tend to exhibit lower CEP scores. In contrast, firms with fewer BI appear to perform better, on average, in managing their carbon emissions. This pattern contradicts the initial expectation that greater board independence would reinforce environmental oversight and thereby enhance carbon outcomes.

Theoretically, this result departs from the predictions of both stakeholder theory and agency theory. From a stakeholder-theoretic perspective, independent directors are expected to be less constrained by managerial or controlling shareholder interests, and thus more responsive to social and environmental concerns. This enables more effective oversight of environmental decisions, leading to improved carbon performance (Shang, 2025). Likewise, agency theory posits that increased board independence should strengthen monitoring, reduce managerial opportunism, and promote more objective decision-making, which in turn is expected to support more credible sustainability reporting and more substantive carbon-related initiatives (Barros et al., 2020). Against this background, the negative association between board independence and CEP observed in this study appears counterintuitive

However, the empirical data in this study show the contrary trend. This outcome may be attributed to a variety of contextual circumstances. First, independent directors generally play a minor role in Indonesia, focusing on regulatory compliance rather than adopting effective governance practices (Mukhtaruddin et al., 2020). Second, having a larger proportion of BI may slow down decision-making processes, particularly for capital-intensive investments in low-carbon technology, due to a preference for caution or risk aversion (Kamarudin et al., 2024). Under such conditions, BI may be associated not with proactive decarbonisation, but rather with delayed or conservative responses to climate-

Jurnal Akuntansi
e-JA
E-ISSN 2549-8800
P-ISSN 1410-3591

related investment needs. Third, the measurement of board independence as the proportion of BI captures structural independence but does not reflect the quality of that independence, including factors such as sustainability expertise, genuine autonomy from controlling shareholders, or willingness and capacity to challenge management (Redor & Blomkvist, 2021).

In comparison to earlier research, these findings diverge from those reported by Oyewo (2023) and Muktadir-Al-Mukit & Bhaiyat (2024), which indicated a positive relationship between board independence and emission reduction. The discrepancy may be attributable to differences in institutional frameworks, governance enforcement, market pressures, the maturity of ESG practices, and sectoral or regional characteristics. By contrast, the results of this study are more closely aligned with those of Musa et al. (2025) who report no significant effect of BI on carbon emission disclosure in Saudi petrochemical companies. This suggests that BI may be largely symbolic or insufficient on its own to drive meaningful environmental change. Overall, the evidence from this study suggests that the effectiveness of board independence as a governance mechanism for improving CEP is highly context-dependent and contingent on the substantive roles, expertise, and incentives of independent directors, rather than merely their numerical representation on the board.

The Moderating Role of Board Independence in the Relationship between ESG Score and Carbon Emission Performance. The empirical results indicate that BI does not moderate the effect of ESG score on CEP. This is reflected in the interaction coefficient of 0.659 with a probability value of 0.056, which is not statistically significant. Furthermore, the model's explanatory power increases only marginally when the interaction term between ESG score and board independence is included, with the R-squared rising from 0.455 to 0.459, an improvement of merely 0.004 (around 0.400 percentage points). This modest change suggests that adding board independence as a moderator does not materially enhance the model's ability to explain variation in carbon emission performance. Taken together, these results imply that, within the sample and period examined, board independence does not significantly strengthen or weaken the relationship between ESG scores and CEP.

Our findings of a weak moderating effect align with the limited empirical evidence that challenges the notion of board independence as the sole determinant in the relationship between ESG and environmental performance. Although research examining the moderating role of BI on ESG and BI remains scarce, existing studies reveal a discernible trend. Shu et al. (2024) argue that BI does not influence the relationship between board interlocks and ESG performance, including carbon-related factors. This suggests that independent directors may not necessarily impact the way governance structures drive ESG outcomes. Likewise, Grau Grau et al. (2025) demonstrate that BI does not always lead to improved carbon emission performance, refuting the assumption that increasing the proportion of BI will enhance corporate decarbonization efforts. These findings imply that formal independence is merely one of several factors influencing the effectiveness of board independence, with other key elements such as sustainability committees, robust institutional and regulatory frameworks, and environmental expertise at the board level playing critical roles.

These empirical findings contradict both agency theory and stakeholder theory. Agency theory posits that non-executive directors are vital in guiding managers to reduce climate and environmental risks while simultaneously increasing long-term shareholder value (Zaid et al., 2020). Independent directors are expected to enhance the effectiveness of ESG practices in reducing carbon emissions via the implementation of credible ESG strategies and the provision of rigorous oversigh (Alkurdi et al., 2024; Ding & Tseng, 2023;

Jurnal Akuntansi
e-JA
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Ihbal et al., 2024). Similarly, stakeholder theory posits that BI are better positioned to balance the interests of multiple stakeholder groups, including those advocating for environmental sustainability. Through the promotion of transparency, accountability, and robust ESG disclosure, independent directors are theorised to strengthen corporate reputation and stakeholder trust, thereby contributing indirectly to improved carbon emission performance (Elsayih et al., 2021; Kim et al., 2023).

The absence of a significant moderating effect in the present study suggests that these theoretical benefits may not fully materialise in practice in Indonesia. A plausible interpretation is that board independence in this context remains formal mainly rather than substantive, independent directors may lack sufficient ESG or environmental expertise, may not be fully empowered to challenge executive decisions, or may prioritise compliance and risk aversion over proactive climate strategy. In such circumstances, ESG performance may be driven primarily by external pressures and internal sustainability functions, with board independence contributing little additional influence on translating ESG scores into superior carbon emission outcomes.

CONCLUSION

The study's findings show how ESG practices could assist firms listed on the Indonesia Stock Exchange in improving their corporate carbon emissions performance. Higher ESG scores are significantly linked to better CEP, indicating that companies prioritizing ESG factors are better able to manage and reduce their carbon emissions. This study supports the idea that ESG activities provide tangible environmental benefits in emerging nations where emissions constraints are increasing, and stakeholder demands for concrete sustainability rather than merely symbolic actions are growing.

However, the study finds that board independence directly affects carbon emissions performance and does not significantly reduce the association between ESG scores and carbon emissions performance. According to these results, board independence by itself does not constitute an adequate governance approach to enhance the positive impacts of ESG practices on carbon outcomes in Indonesia between 2022 and 2024. This inefficiency may be due to contextual variables such as rigid adherence to independence standards. Either a lack of enforcement and monitoring measures or insufficient sustainability expertise among independent directors hinders the potential of independent boards to influence environmental efforts.

The relatively small sample size of companies listed on the Indonesia Stock Exchange, the short research period (2022 to 2024), and the use of secondary data from the Refinitiv Eikon database may limit the generalizability of the results. Additionally, this analysis suggests that other factors such as the regulatory framework, industry context, and specific company activities, may play a more significant role in determining how effectively ESG policies achieve environmental goals. Future research should explore alternative governance strategies, investigate different sectors or geographical regions, and conduct longitudinal studies to clarify the long-term impact of board independence and ESG practices on carbon emissions performance.

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