

Carbon Emission Disclosure, Carbon Performance, and Firm Value: Exploring Intellectual Capital's Role

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Abstract

Purposes: This study investigates the impact of carbon emission disclosure and carbon performance on firm value, with intellectual capital as a moderating variable. The research addresses the increasing importance of sustainability disclosures and their effect on corporate valuation, particularly in the mining sector, which significantly contributes to global carbon emissions.

Methods: This research employs a quantitative method by examining data from 63 mining companies listed on the Indonesia Stock Exchange (IDX) for 2020–2023. Through purposive sampling, 34 companies were selected, resulting in 94 observations. The data were analyzed using unbalanced panel data regression with the help of STATA software.

Findings: The results show that carbon emission disclosure negatively impacts firm value, while carbon performance positively influences firm value. However, intellectual capital does not moderate the relationship between carbon emission disclosure, carbon performance, and firm value.

Novelty: This research highlights the limited role of intellectual capital in enhancing the effects of sustainability practices on firm value, providing new insights into its integration within corporate strategies. It emphasizes the need for companies and policymakers to optimize intellectual capital utilization in sustainability practices to improve corporate value. Future studies could explore other industries or incorporate additional moderating variables for a more comprehensive analysis.

Keywords: Carbon Emissions, Firm Value, Intellectual Capital, Mining Sector, Sustainability.

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INTRODUCTION

The increasing competition in the global economy demands that companies maintain their best performance. Companies need to sustain their existence and enhance their value to shareholders. The primary focus for publicly listed companies aiming to attract investors is how the public perceives their value. Generally, companies have two goals: short-term and long-term. The short-term goal is to generate profits by utilizing available resources, while the long-term goal is to maximize activities to achieve economic prosperity for investors and shareholders by enhancing firm value (Dessyla & Susanti, 2024). One critical factor in increasing investor wealth

is maximizing the firm value (Gunawan & Berliyanda, 2024). The impact on shareholder value can be measured by assessing high rates of return.

In the increasingly complex business development, investors not only consider financial aspects investors not only consider financial aspects, but also they consider non-financial factors such as sustainability issues in today's increasingly complex business environment. Companies that fulfill their obligations to disclose corporate social responsibility (CSR) based on Global Reporting Initiative (GRI) standards tend to experience increased value (Firmansyah et al., 2021). It indicates that investors are paying attention to a company's sustainability, particularly its ability to respond to sustainability challenges. This shift highlights the importance of environmental, social, and governance (ESG) criteria in investment decision-making and their influence on corporate policies and investor expectations.

Sustainability issues, particularly climate change, have become a primary concern for institutional and individual investors. Companies that demonstrate seriousness in implementing sustainability practices in their business operations are more likely to attract investor interest, potentially increasing their long-term value. Recent developments in climate change issues have garnered global attention. Yu et al. (2024) revealed that data from the Intergovernmental Panel on Climate Change (IPCC) estimates that the Earth's average temperature could rise by 0.450°C for every 1,000 gigatons (Gt) of carbon dioxide emitted due to human activities. Compared to the Paris Agreement's target of limiting global temperature increases to 1.5°C, the permissible CO₂ emissions from human activities are capped at 550 Gt in the future.

Within the capital market landscape, climate change is recognized as an environmental concern and a critical source of business risk and opportunity. Modern companies are expected to proactively address climate challenges by lowering greenhouse gas emissions and adapting to the inevitable consequences of a changing climate. These challenges also present opportunities for companies to innovate and respond proactively to sustainability issues, thereby earning the trust of increasingly climate-conscious investors. According to *Our World in Data*, the mining sector is one of the most significant contributors to carbon emissions, accounting for 73.2% of total emissions, making it the most significant source of carbon release worldwide. Additionally, Indonesia ranks fifth among the world's largest carbon emitters, with total carbon emissions reaching 404,572,740.00 tons of CO₂ (Ritchie et al., 2024).

To address these challenges, the Indonesian regulator has set a target to reduce greenhouse gas emissions by 29% by 2030. In line with this commitment, the Financial Services Authority (OJK) issued Regulation No. 51/POJK.03/2017 on implementing Sustainable Finance for Financial Institutions, Issuers, and Public Companies. This regulation mandates companies to disclose sustainability strategies by publishing Sustainability Reports to ensure transparency in corporate environmental performance.

According to OJK Circular No. 30/SEOJK.04/2016, public companies or issuers must provide social and environmental responsibility information in separate reports, such as Social and Environmental Responsibility Reports or Sustainability Reports. Companies can report their carbon emissions in CSR Reports. Safutri et al. (2023) found that, based on 56 observations, the average carbon emission disclosure rate was only 24%. This low level of disclosure reflects companies' lack of awareness in providing such information, driven by a lack of transparency in business reporting, perceptions of high costs, and the voluntary nature of disclosures.

In modern investment practices, carbon disclosure has the potential to become a significant factor for investors. Carbon emission disclosures signal investors that the company is committed to good governance and sustainability. Companies demonstrating this commitment through superior carbon performance are perceived as having better long-term prospects, thereby increasing their value in the eyes of investors. It aligns with recent findings that show that companies disclosing carbon emissions in their annual reports tend to have a higher value than those not disclosing. It highlights the critical role of the market in carbon emission issues that impact firms (Trimuliani & Febrianto, 2023).

As environmental issues, particularly decarbonization, continue to rise, companies must take steps to reduce carbon emissions in response to Regulation No 51/POJK.03/2017 about the Implementation of Sustainable Finance for Issuers. These measures are not merely about compliance but also about safeguarding the company's value. Investors consider not only financial aspects but also non-financial aspects, including a company's sustainability performance. Companies that address decarbonization through carbon disclosure and strong carbon performance can potentially gain competitive advantages that positively influence their value. The growing prominence of social responsibility issues, particularly climate change, has elevated corporate value as a key concern, where a company's response to climate change can influence its market value. The groups interested in the company are not limited to shareholders alone; other stakeholder groups, such as the public, indirectly influence the company (Freeman, 1984). As stakeholders, the public evaluates corporate actions, shaping the company's image in the eyes of the public.

In this context, carbon emission disclosure is critical for demonstrating corporate responsibility towards sustainability and environmental risk management. Proactively disclosing carbon emission information reflects transparency and improves carbon performance through better emission management practices. Strong carbon performance, in turn, enhances the company's reputation among stakeholders. Transparent and accurate carbon emission disclosures reduce uncertainties for investors about environmental impacts, potentially increasing trust and market value. This provides stakeholders with confidence that the company operates with environmental responsibility while promoting internal accountability through transparency in carbon emission disclosure (Imansari et al., 2024).

Conversely, companies that fail to disclose or exhibit poor carbon performance risk significant reputational damage, negatively impacting their value. The link between carbon emission disclosure, environmental performance, and corporate value has become a focal point, as these elements signify the company's commitment to sustainability and its future investment prospects. Investors assess these disclosures and efforts, and their responses directly influence corporate value. Therefore, further research on sustainability issues and their impact on corporate value is essential.

Several studies have examined corporate value concerning environmental issues, such as carbon emission disclosures (Alfayerds & Setiawan, 2021; Bahriansyah & Ginting, 2022; Firmansyah et al., 2021; Gunawan & Berliyanda, 2024; Hardiyansah & Agustini, 2021; Houten & Wedari, 2023; Rahmanita, 2020; Saka & Oshika, 2014; Yan et al., 2020), carbon performance (Adu et al., 2023; Houten & Wedari, 2023; Lee & Cho, 2021; Saka & Oshika, 2014; Trimuliani & Febrianto, 2023; Yan et al., 2020), green accounting (Gunawan & Berliyanda, 2024), and CSR disclosure (Firmansyah et al., 2021; Kesumastuti & Dewi, 2021; Narayana & Wirakusuma, 2021; Raningsih et al., 2018; Rasyid et al., 2022; Soemarsono & Alkausar, 2019; Sulbahri, 2021).

This study aims to empirically examine the independent variables of carbon emission disclosure and carbon performance and their significance to corporate value. According to the IPCC, greenhouse gas emissions drive global temperature increases due to human activities, including industrialization, contributing to global warming and climate change (Norsyifa et al., 2023). Through decarbonization efforts, companies can demonstrate sustainability commitments by transparently reporting emissions and actions taken to mitigate impacts. It fulfills social responsibility obligations, strengthens investor trust, and underscores corporate seriousness in addressing climate change issues.

Previous research on the relationship between carbon emission disclosure and corporate value has yielded positive findings (Alfayerds & Setiawan, 2021; Bahriansyah & Ginting, 2022; Hardiyansah & Agustini, 2021; Rahmanita, 2020; Rusmana & Purnaman, 2020; Trimuliani & Febrianto, 2023). Carbon emission disclosures, including emission reduction plans and year-on-year comparisons, foster stakeholder trust and encourage shareholders to invest in these companies (Hardiyansah & Agustini, 2021). However, other studies show that investors view

carbon emission disclosures unfavorably, perceiving them as costly and unprofitable, with investors doubting the cost efficiency of mitigating global warming (Alsaifi et al., 2020). This inconsistency in findings underscores the need for further investigation into the impact of carbon emission disclosure.

Similarly, studies on the relationship between carbon performance and corporate value show mixed results. The positive effects of carbon performance on corporate value have been reported by Houten and Wedari (2023), Lee and Cho (2021), and Yan et al. (2020). High carbon emissions negatively impact society and the environment, while strong carbon performance aligns with government targets to reduce emissions, fosters goodwill with stakeholders, and enhances corporate image (Houten & Wedari, 2023). Consequently, these companies become more attractive to investors. Conversely, Adu et al. (2023) and Saka and Oshika (2014) found that carbon performance negatively impacts corporate value, suggesting that companies often prioritize public legitimacy over substantive emission reduction efforts. Significant carbon emissions and high operational costs to reduce them in the future may lead to adverse perceptions among environmentally aware investors (Adu et al., 2023). These contradictory findings warrant further exploration of the influence of carbon performance on firm value.

This study also incorporates intellectual capital as a moderating variable to investigate the significance of carbon emission disclosure and carbon performance on firm value. Wernerfelt (1984) argued that a company's competitive advantage can be achieved through competent internal resources and capabilities. Previous research examining the relationship between intellectual capital and firm value, such as Dewi & Husain (2019) and Salvi et al. (2020), found a positive influence. A company's efficient utilization of intellectual capital provides significant added value in the eyes of investors, comprising three components: human capital, structural capital, and employee capital (Dewi & Husain, 2019). With intellectual capital, competent resources enhance a company's willingness to disclose carbon performance voluntarily. Therefore, by including this moderating variable, the study aims to offer novel insights into the influence of carbon emission disclosure and carbon performance on firm value. These factors are potential competitive advantages that significantly affect a company's valuation.

According to stakeholder theory, the primary goal of a business entity is to gain optimal support from all parties interested in its activities (Kesumastuti & Dewi, 2021). In line with this, Choi and Luo (2021) revealed that business entities' disclosure of carbon emissions can be perceived as concrete steps companies take to reduce their carbon emissions. Other studies suggest that carbon emission disclosure is a way for companies to respond to stakeholder demands regarding climate risk assessment and the alignment of implemented climate policies (Borghei, 2021).

Carbon emission disclosure consists of data detailing past corporate carbon emissions, future emission projections, and explanations of the financial impacts of climate change on the company (Alfayerds & Setiawan, 2021). Environmental issues have increasingly become a significant concern in accounting, as the information companies disclose can significantly impact their reputation and operational sustainability. With growing public and stakeholder awareness of environmental issues, companies that are transparent in carbon emission disclosure have the potential to earn greater trust from consumers and investors.

Thus, carbon emission disclosure functions as a communication tool and a means of building corporate trust and credibility, ultimately contributing to increased firm value. Carbon emission disclosure has been shown to impact firm value positively Rahmanita (2020), consistent with the notion that stakeholders view such disclosure as a form of corporate responsibility in addressing environmental damage (Hardiyansah & Agustini, 2021). When companies actively communicate the steps, they are taking to manage carbon emissions, their reputation is enhanced in the eyes of the public and stakeholders. Consequently, the company's stock price in the market rises along with increased stakeholder confidence.

H₁: Carbon emission disclosure has a positive effect on firm value

From the consumers' and other stakeholders' perspectives, companies that work to reduce carbon emissions demonstrate responsibility and commitment to sustainability. In line with stakeholder theory (Freeman, 1984), companies must balance the interests of all parties directly or indirectly involved with their business activities to achieve their goals. Carbon performance is the quantitative measurement of greenhouse gases contributing to climate change and companies' efforts and processes to reduce those emissions (Trimuliani & Febrianto, 2023). It can be measured by the natural logarithm of Sales to Carbon Disclosed (Ton/CO₂) (Luo, 2019). In other words, carbon performance represents corporate efforts to reduce carbon emissions or engage in decarbonization to support sustainability issues. Many companies actively address environmental issues to differentiate themselves from competitors and gain a competitive edge. Positive market responses to these efforts are an important sustainability strategy that ultimately contributes to the growth of their stock value.

Saka & Oshika (2014) reported a negative influence, while other research demonstrated that voluntary carbon performance disclosures enhance firm value. Carbon performance can negatively impact a company's value because the mining sector focuses on achieving high profit margins. Companies prioritizing decarbonization efforts may struggle to achieve cost efficiency, as these initiatives often require significant investments in cleaner technologies and sustainable practices. As a result, higher operational costs can lead to reduced profitability, ultimately causing a decline in the company's value. On the other hand, by adopting environmentally friendly practices and being transparent about carbon emission disclosures, companies attract environmentally conscious consumers and build investor trust, increasing corporate value (Yan et al., 2020). These practices can drive firm value growth in the market as demand for sustainable investments rises. Additionally, companies proactively addressing environmental issues are better equipped to handle risks arising from regulatory changes or social pressures, creating a more stable foundation for long-term growth.

H₂: Carbon performance has a positive effect on firm value

According to the Resource-Based View theory (Barney, 1986), valuable, rare, and inimitable resources form the basis for a sustainable competitive advantage for an organization. Intellectual capital, encompassing employees' knowledge, skills, and experiences, as well as organizational innovation and unique processes, represents resources that meet these criteria. When intellectual capital is considered valuable, it significantly contributes to value creation and achieving a company's strategic objectives. Intellectual capital is an intangible asset that enables companies to execute their strategies effectively and efficiently (Nidaurrifa et al., 2024). These intangible resources are divided into three components: human capital, structural capital, and customer capital (Bontis et al., 2000).

Previous research has demonstrated that intellectual capital positively influences firm value (Salvi et al., 2020). In the era of a knowledge-based economy, intangible assets like intellectual capital serve as resources that enhance firm value. By improving their resource capabilities, companies gain a competitive edge and strengthen their market position. Furthermore, intellectual capital includes customer and market knowledge, enabling companies to respond more effectively to consumer needs.

Companies with competent resources tend to exhibit higher levels of carbon performance disclosure. In this context, companies with expertise in carbon emission management can provide more transparent and accurate disclosures. It helps them meet regulatory requirements and enhances their reputation and stakeholder trust. Intellectual capital also enables companies to be more responsive to emerging environmental issues. As Freeman (1984) highlighted, stakeholders

consider corporate decarbonization efforts, which impact the company's image and ultimately influence its market value.

H₃: Intellectual capital strengthens the positive effect of carbon emission disclosure on firm value

The Resource-Based View theory introduced by Wernerfelt (1984) suggests that companies must adopt effective strategies to manage and access their strategic resources or assets. Intellectual capital is regarded as an intangible asset that, although not explicitly recorded on the company's balance sheet, positively affects its performance (Ozkan et al., 2017). A company's ability to generate profits is evaluated by its profit and by comparing the profit generated and the equity utilized to achieve it (Budiningtyas & Hutabarat, 2024). Assessing a company's financial performance requires consideration of how effectively capital is employed. In other words, high profits do not necessarily reflect good performance if achieving them requires substantial capital investment. Intellectual capital represents resources with competencies and skills to create and enhance firm value (Ulum, 2015). When companies utilize intellectual capital optimally, they can foster innovation, improve operational efficiency, and enhance product or service quality. It contributes to short-term value creation and helps establish sustainable competitive advantages.

Companies that commit to sustainability and carbon emission reduction can achieve market differentiation. Environmentally conscious customers are more likely to choose products from socially responsible companies. By adopting environmentally friendly practices and being transparent in disclosing carbon emissions, companies attract consumers concerned about sustainability issues and build investor trust, increasing the company's value (Yan et al., 2020). These efforts create long-term value, making companies more competitive in an ever-evolving market. Thus, carbon emission management enables companies to achieve sustainable competitive advantages. By investing in environmentally friendly practices, companies meet market demands and attract shareholders seeking sustainable investment opportunities. This approach opens access to better funding sources, reduces operational costs through energy efficiency, and strengthens the company's financial performance. At the same time, it supports global efforts to combat climate change, further solidifying the company's market position.

H₄: Intellectual capital strengthens the positive effect of carbon performance on firm value

Based on the previously discussed theoretical framework and formulated hypotheses, the research model is presented in Figure 1.

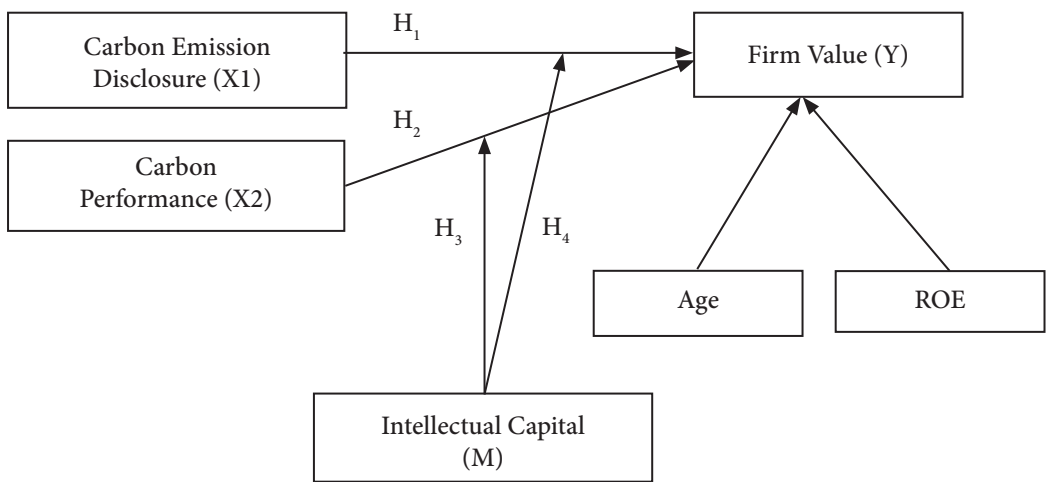


Figure 1. Research Model

METHODS

This study employs secondary quantitative data, which refers to information collected, analyzed, and reported by external parties to support research activities (Cooper & Schindler, 2019). The data is sourced from annual and sustainability reports of mining sector companies listed on the Indonesia Stock Exchange (IDX) during 2020–2023. These years were chosen for this study because, according to Regulation No. 51/POJK.03/2017, listed companies were required to start reporting their sustainability financial information in their sustainability reports no later than 2020. These reports were obtained from the official IDX website (idx.co.id) and the official websites of the respective companies. The mining sector was selected as the focus of this study due to its significant contribution to global carbon emissions. According to the Global Carbon Budget report by Ritchie et al. (2024), Indonesia ranked fifth globally in 2022 as one of the most significant contributors to carbon emissions from coal. This study focuses on sub-industries, including coal production, oil and gas production and refining, gold, iron and steel, diversified metals and minerals, copper, and aluminium. These sub-industries were chosen for their substantial role in generating carbon emissions, making them highly relevant for examining the relationship between carbon emission disclosure, carbon performance, and firm value.

A purposive sampling approach was employed to determine the sample based on specific criteria relevant to the research objectives, as shown in Table 1. From an initial population of 63 companies listed on the IDX during the four years of observation (2020–2023), 252 observations were obtained. However, after screening based on criteria such as the publication of sustainability reports, including carbon emission information in reports and positive Value Added (IN-OUT) metrics, the final sample consisted of 94 data points from 35 companies.

Table 1. Sample Elimination

No	Criteria	Total
1	Mining firms registered on the IDX between 2020 and 2023	63
2	Number of observation years	4
3	Total population	252
4	Mining sector firms that did not release their Annual and/or Sustainability Reports throughout the 2020–2023 period	(88)
5	Mining sector companies that did not include information on the use of Greenhouse Gas (GHG) in their Annual and Sustainability Reports during 2020–2023	(63)
6	Mining sector companies with negative Value Added (IN-OUT)	(7)
7	Total Sample	94

Source: Data Processed (2024)

This research employs Tobin's Q as the dependent variable to represent firm value, capturing the company's potential for growth and investment opportunities, following prior research by Adu et al. (2023), Dewi and Husain (2019), Hatane et al. (2019), Rahmanita (2020), and Salvi et al. (2020). Tobin's Q ratio indicates market conditions, which are often reflected in stock prices and influence value fluctuations. The formula for Tobin's Q is:

$$\text{Tobin's Q} = \frac{\text{Equity Market Value} + \text{DEBT}}{\text{Total Asset Replacement Value}} \dots\dots\dots(1)$$

Carbon emission disclosure is the first independent variable that includes a company's carbon performance and future strategies for carbon reduction. Following Wang (2023), companies report these disclosures using frameworks such as the Carbon Disclosure Project (CDP). This study adopts the disclosure index developed by Choi et al. (2013), which scores firms

on categories like risks and opportunities, GHG emissions, energy consumption, gas reduction and costs, and carbon accountability. The disclosure score is calculated as follows:

$$CED = \left(\frac{\sum di}{M} \right) \dots\dots\dots (2)$$

Carbon Emission Disclosure ($\sum di$) is the total score for disclosed items, and MM is the maximum number of disclosure items (18). As the second independent variable, carbon performance is essential for environmental management, and firm valuation is evaluated using emission intensity, following Luo (2019) and Yan et al. (2020). This study uses a negated logarithmic calculation to ensure positivity in comparisons with financial values:

$$CEI = -1 \ln \frac{\text{Total Carbon Emission}}{\text{Total Sales of The Firm}} \dots\dots\dots (3)$$

Total carbon emissions are measured in tons (scope 1 and 2), and total sales are in rupiah. As the moderating variable encompassing knowledge, skills, innovation, and organizational processes, intellectual capital enhances a firm's adaptability and long-term value. Using the Modified Value-Added Intellectual Coefficient (MVAIC) model (Ulum, 2015), this study incorporates relational capital alongside the traditional VAIC components to evaluate intangible assets. MVAIC is computed as:

$$MVAIC = HCE + SCE + RCE + CEE \dots\dots\dots (4)$$

The HCE, SCE, RCE, and CEE represent human, structural, relational, and capital efficiencies. The calculation of Value Added (VA) is obtained by subtracting total costs (excluding employee expenses) from total revenue ($VA = \text{OUT} - \text{IN}$). Human Capital Efficiency (HCE) is calculated as the ratio of value added to employee expenses ($HCE = VA/HC$), where VA is the value added and HC is the employee expense. Structural Capital Efficiency (SCE) is determined by dividing structural capital, the difference between value-added and human capital ($VA - HC$), by value added. Relational Capital Efficiency (RCE) is measured as the ratio of relational capital, represented by marketing expenses, to value added. Finally, Capital Employed Efficiency (CEE) is the ratio of value added to net equity ($CEE = VA/CE$).

Control variables consist of firm age and profitability. Firm age, calculated as $\text{Firm Age} = \text{Research Year} - \text{IPO Year}$, reflects the company's longevity and experience in the market (Susanti & Restiana, 2018). It indicates stability and resilience in market dynamics, particularly for mining companies transforming post-IPO. Profitability is measured using Return on Equity (ROE), which evaluates a firm's ability to generate net income relative to shareholders' equity. ROE is preferred over ROA for its focus on equity funding sustainable operations (Narayana & Wirakusuma, 2021). The formula for ROE is:

$$ROE = \frac{\text{Net Income}}{\text{Total Equity}} \dots\dots\dots (5)$$

This study employs a multiple linear regression model using unbalanced panel data. Unbalanced panel data refers to datasets where the number of observations for each cross-sectional unit (e.g., companies) varies over time. This approach allows for the inclusion of companies that may not have complete data for all periods, ensuring the analysis remains comprehensive without excluding valuable information. The multiple linear regression model used in this study, as outlined in Table 2, is formulated as follows:

$$TBQ_{it} = \alpha + \beta_1 CED_{it} + \beta_2 CP_{it} + \beta_3 IC_{it} + \beta_4 CED_{it} * IC_{it} + \beta_5 CP_{it} * IC_{it} + \beta_6 AGE_{it} + \beta_7 ROA_{it} + \varepsilon_{it} \dots\dots\dots (6)$$

Where: TBQ = Firm Value; α = Constant; CED = Carbon Emission Disclosure; CP = Carbon Performance; IC = Intellectual Capital; AGE = Firm Age; ROE = Profitability.

Table 2. Operational Variable

Variable	Ref	Proxy
Firm Value	(Adu et al., 2023; Dewi & Husain, 2019; Hatane et al., 2019; Salvi et al., 2020)	$Tobin's\ Q = \frac{Equity\ Market\ Value + DEBT}{Total\ Asset\ Replacement\ Value}$
Carbon Emission Disclosure	(Choi et al., 2013)	$CED = \left(\frac{\sum di}{M} \right)$ $\sum di = Total\ disclosures\ made\ by\ the\ company$ $M = Maximum\ Disclosure$
Carbon Performance	(Luo, 2019) (Yan et al., 2020)	$CEI = -1\ Ln \frac{Total\ Carbon\ Emission}{Total\ Sales\ of\ The\ Firm}$
Intellectual Capital	(Ulum, 2015)	$MVAIC = HCE + SCE + RCE + CEE$ $HCE = Human\ Capital\ Efficiency$ $SCE = Structural\ Capital\ Efficiency$ $RCE = Relational\ Capital\ Efficiency$ $CEE = Capital\ Employed\ Efficiency$
Return on Equity	(Narayana & Wirakusuma, 2021)	$ROE = \frac{Net\ Income}{Total\ Equity}$
Firm Age	(Susanti & Restiana, 2018)	$AGE = Research\ Year - IPO\ Year$

Source: Data Processed (2024)

RESULTS AND DISCUSSIONS

Descriptive statistical analysis evaluated the data by estimating the observed objects without concluding. This analysis includes each variable’s mean, standard deviation, maximum, and minimum values. Table 3 presents the descriptive statistics, summarizing the dataset and highlighting key characteristics of each variable. The average firm value, represented by Tobin’s Q (TBQ), is 1.891, indicating that, on average, firms’ market values are approximately 1.89 times their replacement costs. However, the high standard deviation of 2.707 reflects substantial variation among firms. The lowest observed TBQ is 0.583, suggesting some firms are undervalued, while the highest value of 15.361 indicates significant overvaluation for specific firms. Carbon emission disclosure (CED), with a mean score of 0.670, shows that, on average, firms disclose 67.08% of the items in the disclosure index. The standard deviation of 0.181 reflects moderate variation in disclosure practices, with scores ranging from 0.333 (low disclosure) to 1 (full disclosure). Carbon performance (CP) has a mean score of 18.333, indicating average emission intensity,

Table 3. Descriptive Statistics

Variable	Obs	Mean	Std. Dev	Min	Max
TBQ	94	1.891	2.707	0.583	15.361
CED	94	0.670	0.181	0.333	1
CP	94	18.333	2.820	13.935	29.896
MVAIC	94	20.491	29.387	0.650	185.053
ROE	94	0.226	0.407	-2.543	1.246
AGE	94	15.734	8.980	2	34

Source: Output Stata (2024)

with a standard deviation of 2.820 showing moderate variability. The scores range from 13.935 to 29.896, reflecting firm carbon management efficiency differences.

The Modified Value-Added Intellectual Coefficient (MVAIC) averages at 20.491, suggesting a strong emphasis on intellectual capital utilization among firms. However, the high standard deviation of 29.387 indicates considerable variability, with scores ranging from 0.650 to 185.053, reflecting significant differences in firms' intellectual resource efficiency. Profitability, measured by return on equity (ROE), averages at 0.226, meaning firms generate an average 22.67% return on shareholders' equity—however, the standard deviation of 0.407 highlights substantial variability. The lowest ROE is -2.543, indicating losses for some firms, while the highest value is 1.246, showing a 124.66% return for the most profitable firms.

The average firm age (AGE) is 15.734 years, indicating that most firms in the sample have been publicly listed for over 15 years. The standard deviation of 8.980 reflects diversity in firm age, ranging from 2 years for the youngest firm to 34 years for the oldest. This variability across variables provides a comprehensive dataset for analyzing the relationships between firm value, carbon management practices, intellectual capital, profitability, and age. The results highlight the heterogeneity among mining sector firms in strategic focus and operational outcomes, which is critical for further analysis.

Furthermore, the classical assumption testing was conducted, and it was determined that the data successfully passed the normality and correlation tests. The skewness and kurtosis tests showed skewness < 3 and kurtosis < 10, with winsorization applied to some previously abnormal data. For the correlation test, the results indicated values no greater than 0.8 and no less than -0.8. Therefore, it can be concluded that the data has passed the classical assumption tests. Heteroscedasticity and autocorrelation tests were not conducted, considering that the regression model used is the Random Effect Model, which is therefore considered BLUE (Best Linear Unbiased Estimator). Table 4 summarizes the hypotheses test results using a random effects model in panel data regression.

Table 4. The Summary of Hypotheses Test

Var	Coef.	t	Prob	Significance Levels
C	-0.057	-0.05	0.481	
CED	-1.282	-2.24	0.012	**
CP	0.134	2.1	0.018	**
MVAIC	-0.005	-0.51	0.304	
CED*MVAIC	0.023	1.17	0.121	
CP*MVAIC	-0.000	-1.38	0.084	*
ROE	1.147	2.72	0.003	***
AGE	-0.014	-0.91	0.182	
Number of obs	94			
R-square	0.209			
Prob > F	0.002			

Significance levels are indicated as *** (1%), ** (5%), and * (10%)

Source: Output Stata (2024)

The Effect of Carbon Emission Disclosure on Firm Value

The regression results presented in Table 4 and Table 5 indicate that carbon emission disclosure exerts a negative and statistically significant influence on firm value. This finding contrasts with the first hypothesis, which proposed a positive association between carbon emission disclosure and firm value, so H_1 is rejected. This finding contradicts several prior studies, including those by Hardiyansah and Agustini (2021), Trimuliani and Febrianto (2023), and Rusmana and

Purnaman (2020), which found positive relationships between carbon emission disclosure and firm value. However, it aligns with research by Lee et al. (2015), which identified a negative effect of carbon emission disclosure on firm value. It indicates that investors may perceive such disclosures as a negative signal, raising concerns about the costs associated with addressing global warming and their impact on profitability.

Table 5. Results of Hypotheses Testing

No	Hypothesis	Expected Sign	Test Results	Conclusion
1	Carbon Emission disclosure has a positive effect on firm value.	+	-	H1 rejected
2	Carbon performance has a positive effect on firm value.	+	+	H2 accepted
3	Intellectual capital strengthens the positive influence of carbon emission disclosure on firm value.	+	0	H3 rejected
4	Intellectual capital strengthens the positive influence of carbon performance on firm value.	+	-	H4 rejected

Source: Data Processed (2024)

Stakeholder theory emphasizes that businesses are not solely responsible for generating profit but also have obligations to benefit various stakeholders (Kesumastuti & Dewi, 2021). Stakeholders, whether directly or indirectly involved, can pressure companies to act in ways that serve their interests. While investors traditionally focus on profitability, modern stakeholders increasingly demand compliance with regulations and adopting sustainable practices. Climate change has become a global concern, and companies addressing this issue will likely enhance their attractiveness to investors and improve their public image by showing environmental responsibility.

Carbon emission disclosure is guided by the Carbon Emission Index issued by the Carbon Disclosure Project (CDP), which consists of 18 indicators related to climate risk, greenhouse gas emissions, energy consumption, emission reduction, and carbon cost accountability (Choi et al., 2013). Companies disclose their performance in sustainability reports as mandated by Regulation No. 51/POJK.03/2017 on sustainable finance. Each disclosed item contributes to the total score, divided by 18, to produce a disclosure ratio.

The findings of this study reveal that the company with the highest firm value, PT Bayan Resources Tbk, had a value of 15.361 but disclosed only 13 out of 18 items in 2023. In contrast, companies with full disclosure, such as PT Indika Energy Tbk (disclosure ratio of 1), had significantly lower firm values of 0.718 in 2023, and PT Aneka Tambang Tbk recorded 1.460 in the same year. These results demonstrate that higher carbon emission disclosure tends to be associated with lower firm value, supporting the conclusion that such disclosures negatively impact a company's valuation.

Furthermore, Firmansyah et al. (2021) argued that investors often do not fully align with companies' perspectives on social responsibility disclosure. The additional costs incurred by companies to meet the standards set by POJK No. 51/2017 or CDP requirements may reduce profitability and be seen as a marketing effort to improve public image rather than a genuine commitment to sustainability. Carbon emission information has not yet become a critical factor for investors. Companies may be reluctant to disclose more data due to fears that the response from stakeholders, particularly investors, will not meet expectations. This situation is exacerbated by the lack of strict regulations mandating carbon emission disclosure, particularly in the mining sector. Since such disclosures are voluntary, many high-emission companies fail to report this information consistently. It underscores the need for more stringent policies to encourage transparency regarding environmental impacts.

Regulation No. 51/POJK.03/2017 enforcement should be reconsidered or delayed, especially for sectors with substantial environmental impacts. In the mining sector, stakeholders focus on cost margins rather than sustainability practices. Clearer regulations could motivate companies to disclose their environmental performance, ultimately helping investors make more informed decisions and fostering broader support for sustainable practices.

The Effect of Carbon Performance on Firm Value

The regression analysis conducted in this study concludes that carbon performance significantly affects firm value. This finding supports the acceptance of the second hypothesis (H_2), which states that better carbon performance increases firm value. The result aligns with prior research by Lee and Cho (2021), Trimuliani and Febrianto (2023), and Houten and Wedari (2023), which also found that carbon performance positively impacts market value. Active participation in carbon emission reduction provides dual benefits. It helps companies build and maintain a strong reputation among consumers and stakeholders (Trimuliani & Febrianto, 2023) while demonstrating their commitment to decarbonization efforts, benefiting the environment and society.

Stakeholder theory provides a framework for understanding the link between carbon performance and firm value, highlighting the importance of balancing the interests of all stakeholders, both directly and indirectly involved in the company's objectives (Freeman, 1984). A company's dedication to promoting decarbonization initiatives can enhance its value, particularly as stakeholders increasingly prioritize environmental concerns amidst growing attention to sustainability issues. Carbon performance serves as an indicator of a company's efforts toward decarbonization. It is measured using the inverse natural logarithm of the ratio of carbon emissions (measured in tons of CO₂ equivalent) to total sales. This approach modifies the measurements previously applied by Yan et al. (2020) and Luo (2019), reflecting a company's commitment to reducing carbon emissions relative to its annual sales.

This conclusion is reinforced by data observations showing that firms with high carbon performance efficiency tend to have higher firm values. For example, a high firm value will accompany a company with good carbon efficiency. This can be seen in PT Baramulti Suksessarana in 2021, which had a carbon performance value of 28.658 and a firm value of 2.564. Conversely, PT Adaro Energy Tbk 2023 experienced a decline in firm value to 0.759, alongside a lower carbon performance efficiency of 18.282. These findings underscore that improved carbon performance positively influences firm value. This finding supports prior studies, which suggest that the positive impact of carbon performance on firm value stems from investors' belief that reducing carbon emissions delivers dual advantages. These benefits include helping companies build and maintain a good reputation among consumers and other stakeholders (Trimuliani & Febrianto, 2023).

The chosen industrial sector can also positively impact carbon performance and firm value. Investors' attitudes in the mining sector, prioritizing net profit in the context of carbon efficiency, can be accommodated through the company's decarbonization efforts. As a result, the costs previously incurred in the production process must be reduced to meet carbon efficiency targets. One example of a decarbonization strategy is the adoption of solar panels for energy needs. It reduces reliance on fossil fuels and leads to long-term operational cost savings. Furthermore, including current sales as a measurement instrument highlights that good carbon performance can also positively impact net income. Companies with high carbon emissions often incur higher operating costs, but efforts to reduce carbon intensity contribute to sustainability and environmental responsibility, ultimately improving profitability and firm value.

The Moderating Role of Intellectual Capital in the Effect of Carbon Emission Disclosure on Firm Value

The regression analysis reveals that carbon emission disclosure negatively impacts firm value. This finding suggests that intellectual capital fails to either strengthen or weaken the effect of carbon emission disclosure on firm value, leading to the rejection of the third hypothesis (H_3).

The interaction between intellectual capital and the effect of carbon emission disclosure on firm value can be understood through the Resource-Based View Theory. Developed by Wernerfelt (1984), this theory posits that companies aim to create unique value that distinguishes them from competitors. A company's commitment to sustainability, whether through regulatory compliance or adherence to specific standards, can be an intangible asset that enhances its competitive advantage. Intellectual capital, as defined by Pulic (2000), is an asset that generates added value for companies and supports managerial efforts to address sustainability issues. Firms with robust intellectual capital can enhance the extent and quality of their carbon emission disclosures.

In this study, the mining sector companies exhibit significant disparities in intellectual capital. The average intellectual capital score among the sampled companies is 20.491, with the highest and lowest scores being 185.053 and 0.650, respectively. This wide gap highlights substantial differences in intellectual capital across firms within the same sector. These results diverge from the findings of Salvi et al. (2020), which demonstrated that intellectual capital positively influences firm value by enabling companies to provide higher-quality information to investors. Such quality information enhances resource allocation efficiency and improves investors' and markets' perception of a company's future growth potential. High intellectual capital allows firms to integrate tangible and intangible resources effectively, showcasing their ability to generate long-term cash flows through a comprehensive business model encompassing inputs, activities, outputs, and outcomes.

On the other hand, this study aligns with Dewi and Husain (2019), who found that intellectual capital does not significantly impact firm value. Several possible explanations exist for why intellectual capital does not moderate the relationship between carbon emission disclosure and firm value. One explanation is that many investors prioritize short-term financial results over the long-term benefits of intellectual capital. When companies disclose their carbon emissions, investors often focus on potential penalties or costs rather than the innovation or expertise that the company possesses.

Furthermore, in the mining sector, companies are less likely to emphasize the development of human resources for business innovation compared to sectors like manufacturing, which heavily rely on internal innovation. Mining companies often depend on external specialists rather than fostering in-house intellectual resources. This results in a weaker association between carbon emission disclosure and the additional value that intellectual capital could potentially generate. Consequently, intellectual capital in this context fails to enhance the perceived value of carbon emission disclosures that contribute to firm value.

The Role of Intellectual Capital in Moderating the Effect of Carbon Performance on Firm Value

The regression analysis in this study shows that carbon performance positively and significantly affects firm value. It indicates that intellectual capital weakens the positive effect of carbon performance on firm value, leading to the rejection of the fourth hypothesis (H_4). According to the Resource-Based View Theory (Wernerfelt, 1984), the relationship between intellectual capital and the effect of carbon performance on firm value can be understood through a company's ability to utilize its intangible resources to achieve sustainability goals. Intellectual capital, encompassing knowledge, skills, and innovation, is critical in developing effective strategies for managing carbon emissions. Companies with a deep understanding of eco-friendly technologies and best practices in carbon management can significantly enhance their carbon performance. Enhanced carbon performance helps companies meet regulatory requirements and societal expectations while strengthening their reputation among investors and consumers.

His result is consistent with the study by Hatane et al. (2019), which identified a negative relationship between intellectual capital and firm value. These findings question the foundational assumption of the Resource-Based View, which posits that intellectual capital functions as a strategic asset for engaging key stakeholders, including investors, customers, and society.

Intellectual capital, which includes key elements like knowledge, innovation, and employee skills, is expected to provide competitive advantages. The result suggests that substantial intellectual capital may dilute carbon performance's impact on firm value. It could be due to companies diverting their financial resources and focusing on building competent intellectual resources, thereby reducing attention and investment in sustainability initiatives such as decarbonization. For example, the development of innovations aimed at reducing carbon emissions in the mining sector may be delayed as companies prioritize the cultivation of intellectual capital. As a result, while companies may achieve innovation and market leadership advancements, they risk declining carbon performance. This can also be influenced by the choice of industry and sector being studied (Dewi & Husain, 2019). The companies in that sector prioritize investments that directly impact their profits rather than investing in their resources.

CONCLUSIONS

This study reveals that carbon emission disclosure negatively influences firm value, whereas carbon performance exerts a positive effect. However, intellectual capital does not moderate the relationship between carbon emission disclosure and carbon performance concerning firm value. These results suggest that investors may interpret carbon emission disclosure as a cost burden. In contrast, strong carbon performance is perceived as a tangible demonstration of corporate commitment to sustainability, an attribute the market appreciates.

The research is confined to companies within Indonesia's mining sub-sector, which limits the applicability of the findings to other industries. Furthermore, the relatively small sample size restricts the generalizability of the conclusions. Given that both carbon emission disclosure and carbon performance are voluntary in Indonesia, the availability and reliability of data may be compromised. Future research is recommended to broaden the sectoral coverage and extend the observation period to enhance generalizability. Incorporating other explanatory variables, such as corporate leadership and environmental governance, could enrich the analysis of sustainability's impact on firm value. Alternative research methods, including mixed-method approaches, could offer more comprehensive insights.

Regulatory bodies such as the Financial Services Authority (OJK) are encouraged to enhance sustainability disclosure requirements by mandating more detailed reporting, particularly for industries with substantial environmental footprints. Establishing more straightforward sustainability reporting guidelines and providing incentives for consistent, high-quality disclosures could improve transparency and compliance. These initiatives would contribute to national carbon reduction goals and boost the competitiveness of Indonesian firms in the eyes of global investors.

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