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The Impact of Carbon Performance and Carbon Information Disclosure on Firm Value: Financial Performance as a Mediator in Indonesian Listed Companies

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Abstract

This study aims to provide empirical evidence on whether carbon performance and carbon information disclosure influence firm value, with financial performance serving as a mediating variable in the Indonesian capital market. The research employs a quantitative approach, utilizing secondary data from companies listed on the Indonesia Stock Exchange (IDX). The sample was collected using purposive sampling, comprising 176 companies over the period of 2020–2022, and analyzed using Structural Equation Modeling (SEM) with the SmartPLS program. The results indicate that carbon performance has a significant positive effect on financial performance, measured by ROA and ROE, and on firm value, measured by PBV and Tobin's Q. Carbon information disclosure also shows a significant positive impact on financial performance but an insignificant positive effect on firm value. Financial performance has a significant positive influence on firm value and mediates the positive impact of carbon performance on firm value; however, it does not mediate the relationship between carbon disclosure and firm value.

Keywords: *Carbon Performance, Carbon Information Disclosure, Financial Performance, Firm Value.*

Introduction

Efforts by various parties to prevent climate change through carbon emissions reduction will compel companies to reduce carbon/greenhouse gas emissions from their business operations. Companies are required to cut their carbon emissions while still meeting market demands, thus resulting in fewer carbon emissions produced to satisfy the ever-increasing market demand.

According to the Emissions Database for Global Atmospheric Research (EDGAR), Indonesia ranked as the seventh largest emitter in the world in 2022, after China, the United States, India, the EU27, Russia, and Brazil, with emissions of 1.24 Gt CO2e (gigatons of carbon dioxide equivalent). This figure increased from 1.12 Gt CO2e in 2021 [1].

President Jokowi ratified Presidential Regulation number 98 of 2021 regarding the Implementation of Carbon Economic Value for Achieving Nationally Determined Contribution Targets and Control of Greenhouse Gas Emissions in National Development (PR 98/2021) on October 29, 2021. For Indonesia's climate change policies, PR 98/2021 has become a game-changer, especially in the government's effort to regulate the carbon trading system and develop a sustainable green economy. PR 98/2021 becomes an important sah basis for the government's efforts to meet Indonesia's Nationally Determined Contribution, which is 29% independently and 41% with international collaboration by 2030. Indonesia's efforts in reducing carbon emissions can also be observed from the implementation of the carbon tax on July 1, 2022 [2] .

Lower carbon emissions will enhance carbon performance [3]. Carbon performance describes a company's efforts to reduce their carbon emissions while conducting their managerial activities. Carbon performance correlates positively with market value, thus investors on the Stock Exchange will consider carbon performance when making investment decisions. Investors not only focus on the company's economic

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profits as before but also on climate change issues and social benefits for the company [4] .At the same time, carbon performance involves reducing corporate carbon and even climate change strategies.

A company's responsibility towards the environment is closely related to the company's business sustainability. One form of accountability that a company can undertake is presenting relevant information through transparency in the annual report. This aims to inform stakeholders and serve as a consideration in evaluating the company to ensure its sustainability [5] . Companies that disclose carbon emissions and have environmentally friendly strategies tend to increase public trust in the company, as well as enhance intangible assets and firm value. Carbon emission disclosure is voluntary [3], [6], [7], [8], [9], [10], [11].

According to [12], the disclosure of carbon-related information has a significant impact on the market and firm value. Therefore, companies have an incentive to perform well in sustainability and actively disclose environmental information, as this can positively affect the company's image, attract investor interest, and enhance its stock value. In other words, the measures taken by companies to actively disclose carbon-related information have several positive impacts, such as enhancing trade openness, reducing carbon dioxide emissions, lowering perceived investor risk, increasing confidence in the stock, boosting trading activity in the market, improving stock liquidity, and influencing stock prices and firm value.

Companies that actively disclose carbon information demonstrate their commitment to social responsibility in the eyes of investors. In China, there is a decoupling index. [13] revealed that carbon intensity ranks second among the factors influencing China's decoupling index, including economic growth, carbon intensity, industrialization, energy consumption structure, and consumer price index.

Various authors have investigated the effects of carbon performance and carbon information disclosure on firm value. [3] reported that both carbon performance and carbon information disclosure significantly enhance corporate value. [14] observed a positive correlation between carbon performance and firm value in the capital market. Conversely, [15] noted that while carbon dioxide emissions can negatively impact firm value, voluntary carbon information disclosure has a positive effect. [16] found a negative correlation between carbon emissions and carbon information disclosure with market value. Research conducted in Indonesia, such as by [17] indicated that carbon emission disclosure positively influences firm value. However, [18] found no significant effect of carbon emission disclosure on firm value, while [19] documented a negative impact.

This research contributes to existing theories on the impact of carbon performance and carbon emission disclosure on market and accounting performance. While previous studies have predominantly focused on manufacturing firms, this study includes both manufacturing and non-manufacturing sectors. The findings are anticipated to motivate companies to enhance their carbon performance and transparency in carbon emission reporting. Furthermore, this study aims to provide investors with critical insights into the significance of carbon performance and emission disclosure in their investment decisions. Additionally, the results are expected to support the implementation of the Financial Services Authority Regulation in Indonesia (POJK) No. 51/POJK.03/2017, which mandates sustainable financing practices for financial institutions, issuers, and public companies.

The objective of this study is to explore empirically how carbon performance and the disclosure of carbon-related information impact firm value, with a specific focus on the mediating role of financial performance. This research aims to determine whether financial performance acts as an intermediary between carbon performance, carbon information disclosure, and firm value. By analyzing these relationships, the study seeks to provide insights into how effective carbon management and transparent reporting can empirically influence financial outcomes and subsequently enhance a company's market value. The findings are intended to offer valuable implications for both investors and corporate managers by highlighting the significance of integrating carbon performance and disclosure practices in enhancing firm value, based on empirical evidence.

Based on the above explanation, the researcher is motivated to conduct this study for several reasons. First, previous studies on carbon performance and carbon emission disclosure in relation to financial

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performance and firm value still show inconsistent results. Second, no research has combined the influence of carbon performance and carbon emission disclosure on firm value in Indonesia. Third, there is a phenomenon of international and Indonesian communities driving the movement to reduce carbon emissions. Fourth, by incorporating financial performance as a mediating variable, this study provides a new dimension in connecting ESG factors with firm value. This allows for a deeper understanding of how ESG factors affect financial performance, ultimately influencing investor valuation.

The mediating impact of financial performance on the influence of carbon performance on firm value in companies listed on the Indonesia Stock Exchange in this study is based on the logic that financial performance can serve as a bridge explaining how carbon performance impacts firm value. Specifically, companies with good carbon performance will experience improvements in reputation and operational efficiency, which then contribute to better financial performance. Enhanced financial performance, in turn, can increase the firm's value in the eyes of investors and other stakeholders. Therefore, by examining the mediating role of financial performance, this study seeks to elucidate the detailed mechanisms by which a company's efforts in managing carbon performance can indirectly yet significantly contribute to the enhancement of firm value.

Literature Review

Carbon Emission

Carbon emissions represent the total greenhouse gas emissions produced directly and indirectly by individuals, organizations, events, or products. These greenhouse gases contribute to the greenhouse effect, which has led to global climate change. CO2e emissions encompass several greenhouse gases identified by the Kyoto Protocol, including carbon dioxide (CO2), methane (CH4), nitrous oxide (N2O), perfluorocarbons (PFCs), sulfur hexafluoride (SF6), and nitrogen trifluoride (NF3). Emission intensity from companies is typically reported in mass units of CO2 equivalent (CO2e), such as tons or kilograms of CO2e [20]. Companies generally produce emissions throughout their supply chains, from their operations to the products and services they manufacture and distribute.

Carbon Performance and Carbon Information Disclosure

Carbon performance (CP) refers to the quantitative emissions resulting from managerial activities related to carbon emissions [21]. One way to measure CP is through carbon intensity. According to [20], carbon intensity is calculated by dividing emissions by a relevant measure of activity. This measure can either be revenue, which serves as a common economic denominator, or sector-specific physical production units. [22] argue that using the economic perspective for carbon intensity is more suitable for cross-sectoral analysis and better reflects the carbon efficiency of individual companies.

Carbon information disclosure encompasses both quantitative and qualitative information about a company's past and projected carbon emissions. There is increasing pressure from environmental, business, and political spheres for companies to address the threats posed by extreme global warming [16]. Voluntary disclosure of this information can serve as a positive signal to stakeholders, indicating that companies are transparent about their carbon emissions and responsive to stakeholder needs.

Financial Performance

ROE, ROA, and ROS are ratios that represent financial performance. ROE (Return on Equity) reveals a company's profitability. ROA (Return on Assets) serves as a measure of profitability to assess how effectively a business is utilizing its assets. ROS (Return on Sales) is a ratio used to evaluate the operational efficiency of a business.

According to [23] Return on Equity (ROE) is a financial ratio that measures the profitability of a company in generating net income for its common equity shareholders. The concept of ROE is crucial in financial

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analysis, as it assesses the efficiency with which a company utilizes the funds provided by shareholders to generate profits.

Return on Assets (ROA) is a financial ratio that measures a company's profitability relative to its total assets. ROA indicates how effectively a company utilizes its assets to generate net income. It is calculated by dividing net income by total assets, providing insight into the efficiency of asset use in generating profits. This ratio helps investors and analysts understand how well a company is leveraging its assets to achieve financial success.

Return on Sales (ROS), as described by Brigham, evaluates a company's operational efficiency by showing the percentage of revenue that remains after deducting operating expenses. ROS is calculated by dividing operating profit (or net income) by sales revenue. This ratio provides a clear picture of how well a company controls its costs and manages its operations, ultimately reflecting the company's ability to convert sales into profits.

Firm Value

According to [24], the value of a company is determined by the present value of its expected future cash flows. This approach is based on the concept that a company's worth is fundamentally linked to its ability to generate cash flows over time, which are then discounted to their present value using an appropriate discount rate. This discount rate typically reflects the risk associated with the company's future cash flows. In essence, Ross emphasizes that a company's value is a function of the anticipated earnings and the time value of money, highlighting the importance of both the company's performance and the economic environment in which it operates.

According to [25], firm value can be measured using market value ratios, as these ratios are used to compare the firm's value from an investor's perspective with the value recorded in the financial statements. This value can be measured using several metrics, including Earnings per Share (EPS), Price Earnings Ratio (PER), Price to Book Value (PBV), and Tobin's Q.

Earnings per Share (EPS) is a key financial metric that shows the portion of a company's profit attributed to each outstanding share of common stock. It reflects a company's profitability and is computed by dividing net income by the number of outstanding shares. EPS is crucial for investors as it helps evaluate a company's financial health and performance, providing insights into its ability to generate earnings on a per-share basis.

The Price Earnings Ratio (PER), or Price-to-Earnings Ratio (P/E Ratio), is a ratio used in financial analysis to assess a company's stock valuation. PER is one of the most commonly used financial ratios and is an important tool in determining whether a stock is considered expensive or cheap by investors.

Price Book Value (PBV) is a financial ratio that compares a company's market value to its book value, providing insight into how investors perceive the firm's equity relative to its accounting value. PBV is calculated by dividing the market price per share by the book value per share. It is widely used by investors to assess whether a stock is overvalued or undervalued, indicating the market's expectations about a company's future growth and profitability compared to its historical financial performance.

Tobin's Q is a ratio that compares the market value of a company to the replacement cost of its assets. It is calculated by dividing the market value of a firm's assets by the replacement cost of those assets. A Tobin's Q value greater than one suggests that the market values the company more highly than the cost of its assets, indicating potential overvaluation. Conversely, a value less than one may indicate undervaluation. This ratio is used to assess investment attractiveness and the efficiency of a company's asset utilization.

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Conceptual Model and Hypothesis

The Effect of Carbon Performance on Financial Performance and Firm Value

Carbon performance (CP) refers to the quantitative measurement of emissions resulting from managerial activities that handle carbon output [21]. Reduced carbon emissions enhance CP [3], creating a competitive edge by boosting enterprise value. Companies can legitimize their actions by improving CP, demonstrating their commitment to emission reduction. A focus on lowering carbon emissions helps mitigate environmental harm. Signaling theory highlights the importance of company-generated information for external investors, aligning with studies by [3], [14], [20], [26], [27] and [28] which found that CP positively impacts firm value.

H1: Carbon performance positively affects financial performance.

H2: Carbon performance positively affects firm value.

H6: Carbon performance positively affects firm value through the mediating variable of financial performance.

The Effect of Carbon Information Disclosure on Financial Performance and Firm Value

Carbon information disclosure involves providing both quantitative and qualitative information about a company's past performance and future projections regarding carbon emissions, along with explanations and implications [29]. Companies that disclose their carbon emissions and implement green strategies tend to enhance public trust and increase intangible assets and firm value.

According to stakeholder theory, organizational management is expected to engage in activities deemed important by their stakeholders and report these activities to them. As climate change has become a significant societal concern, there is growing pressure on companies, both directly and indirectly, to disclose environmental information. Since investors assess this information, companies are incentivized to voluntarily disclose it to access high-quality resources. Carbon emission disclosure serves as a form of accountability towards all stakeholders. Consequently, disclosing carbon emissions can provide a competitive advantage by securing stakeholder support, ultimately enhancing the company's value.

This theory aligns with the findings of studies conducted by [16] , [5], [27], and [3] which have shown that the disclosure of carbon information positively influences firm value.

H3: Carbon information disclosure positively affects financial performance

H4: Carbon information disclosure positively affects firm value

H7: Carbon information disclosure positively affects firm value through the mediating variable of financial performance

The Effect of Financial Performance and Firm Value

High profitability reflects strong financial performance and positive corporate prospects, which can lead to a favorable response from investors and, consequently, an increase in corporate value. Thus, financial performance serves as a measure of a company's ability to generate profits.

Research by [20] found that financial performance, as indicated by the Return on Equity (ROE) proxy, has a positive impact on corporate value. Similarly, [3] examined 319 companies which were registered in the Indonesian capital market in 2015. They investigated the effect of financial performance, measured by ROA, ROE and ROI, on corporate value, measured by Tobin's Q, PER, PBV and EPS. Their research indicated

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that financial performance positively influences corporate value. [27], [28] also noted that profitability, as an indicator of corporate financial performance measured by ROE, positively affects corporate value.

Profitability can enhance corporate value but may also diminish it. Expanding operational activities to achieve higher profitability can increase costs, making profitability appear more liquid but less sustainable. Consequently, high profitability does not necessarily ensure the company's long-term survival.

According to [23], corporate profitability refers to a company's ability to generate profits from its investments over a specific period. High profitability indicates strong financial performance and promising prospects for the company, which typically results in a positive response from investors and, consequently, an increase in the company's value [3]. Supporting this, research by [27], [28] demonstrates that financial performance, as indicated by the Return on Equity (ROE) proxy, positively impacts corporate value.

H5: financial performance positively affects firm value

The conceptual model illustrated in Figure 1 consists of four constructs. The exogenous constructs are carbon performance and carbon information disclosure. The endogenous construct is firm value. Financial performance is hypothesized as a mediating construct between the exogenous and endogenous constructs. Specifically, the model examines how carbon performance and carbon information disclosure impact firm value, and the mediating role of financial performance in transmitting this relationship. The proposed hypotheses are that carbon performance and carbon information disclosure each have a direct positive effect on financial performance and firm value. Additionally, financial performance is expected to mediate the impact of the two exogenous constructs on the endogenous construct.

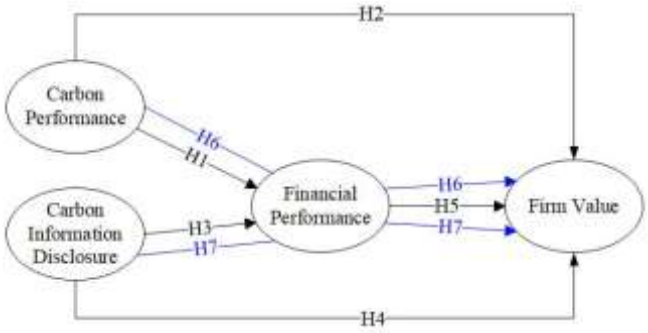

Figure 1. Research Model

Method

The sample was selected using criteria based on specific judgments or quotas , including companies listed on the Indonesian Stock Exchange that issue financial statements and sustainability reports. Additionally, these companies must disclose the amount of carbon/greenhouse gas emissions, including at least one item in carbon emission disclosure, in their sustainability reports for the period from 2019 to 2022.

To ensure the accuracy and relevance of the study, a non-probability sampling technique, specifically purposive sampling, resulting in a total sample of 176. This method involves selecting units based on specific criteria to ensure that the sample population represents characteristics considered crucial for the research. In this context, companies listed on the Indonesia Stock Exchange between 2019-2022, which provided comprehensive information related to the study variables, were included in the sample.

The data analysis in this study is quantitative, aiming to test the formulated hypotheses. The researchers utilize the Structural Equation Model (SEM) analysis technique with SmartPLS version 3.0. According to [30], PLS-SEM can handle both reflective and formative measures without identification issues. In PLS, two models need to be analyzed: the outer model, also known as the measurement model, and the inner model, or structural model. Hypothesis testing is performed through a comprehensive analysis of the

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Structural Equation Modelling (SEM) using SmartPLS. The full SEM model not only validates the theory but also elucidates the presence or absence of relationships among latent variables.

The dependent variable used in this study was firm value, such as Earning per Share (EPS), Price earning ratio, Price Book Value, Tobin's Q.

$$EPS = \frac{\text{Net Income}}{\text{Outstanding Common Shares}} \quad (1)$$

$$PER = \frac{\text{Price per Share)}}{\text{Earning Per Share (EPS)}} \quad (2)$$

$$\text{Price Book Value} = \frac{\text{Price per share}}{\text{Book value per share}} \quad (3)$$

$$\text{Tobin's Q} = \frac{(\text{number of shares x price of shares}) + \text{total liability}}{\text{total liability} + \text{total equity}} \quad (4)$$

The mediating variable used in this study was financial performance, such as Return on Assets (ROA), Return on Equity (ROE), Return on Sales (ROS).

$$ROA = \frac{\text{Net Income}}{\text{Total Assets}} \quad (5)$$

$$ROE = \frac{\text{Net Income}}{\text{Total common Equity}} \quad (6)$$

$$ROS = \frac{\text{Net Income}}{\text{Total Revenue}} \times 100\% \quad (7)$$

The independent variables in this research were carbon performance (CP) and carbon information disclosure (CID). One approach to assess CP is through carbon intensity. As noted by [20], carbon intensity is determined by dividing emissions by a pertinent measure of activity. In this study, CP is quantified using carbon intensity. This measurement method is consistent with the approach taken by [3].

$$\text{Carbon Performance} = \frac{1}{\left(\frac{\text{Corporate carbon emissions}}{\text{Business income}}\right)} \quad (8)$$

Carbon emission disclosure was evaluated through content analysis, utilizing a checklist derived from the research of [16]. The checklist was crafted based on a questionnaire distributed by the CID, encompassing five primary categories: climate change, greenhouse gas emissions, energy consumption, reduction of greenhouse gas emissions and associated costs, and carbon accountability. Each category was divided into 18 specific disclosure items. The index's weighting formula is defined as follows:

$$CID = \frac{\text{Number of scores of entity i in period t}}{\text{maximum total number of scores}} \text{ x } 100\% \quad (9)$$

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Result and Discussion

The sample size in this study consists of 176 data points. The descriptive statistics for the study variables are as follows: The mean value for Carbon Performance (CP) is 7.685, with a median of 7.580, a standard deviation of 1.515, and skewness of 0.274, indicating a slight positive skew. Carbon Information Disclosure (CID) has a mean of 0.511, a median of 0.556, a standard deviation of 0.267, and a skewness of -0.409, showing a moderate negative skew. Return on Assets (ROA) shows a mean of 0.076, a median of 0.033, a high standard deviation of 0.202, and is heavily positively skewed with a skewness of 4.710. Return on Equity (ROE) has a mean of 0.142, a median of 0.087, a standard deviation of 0.499, and a skewness of 0.311, suggesting a mild positive skew.

Return on Sales (ROS) has a mean of 0.114, a median of 0.104, a standard deviation of 0.426, and a skewness of -2.949, indicating a strong negative skew. Earnings Per Share (EPS) shows a high mean of 4497.183 and a median of 73.775, with a substantial standard deviation of 39989.386, and is highly positively skewed with a skewness of 11.147. Price-Earnings Ratio (PER) has a mean of 4.241, a median of 0.053, an extremely high standard deviation of 47.805, and a skewness of 12.661, indicating a highly positive skew.

Price to Book Value (PBV) records a mean of 2.812, a median of 0.958, a standard deviation of 7.163, and a skewness of 4.349, also showing a significant positive skew. Finally, Tobin's Q has a mean of 1.354, a median of 0.986, a standard deviation of 1.465, and a skewness of 4.219, demonstrating a positive skewness as well. These statistics reflect a varied distribution across the variables, with several showing significant skewness and high variability.

Building on this foundational knowledge, the research advanced to more sophisticated analyses, including an examination of the measurement and structural models. Assessing the measurement model is essential to verify the validity and reliability of the indicators, determining the extent to which these indicators accurately represent their respective constructs. On the other hand, the analysis of the structural model delves into the relationships between latent constructs, ensuring the model's structural integrity and clarifying the interconnections among various research elements.

The Partial Least Squares (PLS) method for structural equation modeling (SEM) is particularly advantageous in exploratory studies, as it facilitates the identification of causal relationships rather than merely confirming established models. Additionally, SmartPLS is well-suited for handling data that do not follow a normal distribution, a common occurrence in many business research contexts. Another strength of this approach is its ability to accommodate both formative and reflective latent variables, offering flexibility in the measurement of concepts that have complex and varied indicators.

Outer Model (Measurement Model)

In the subsequent stage of the research analysis, the focus is placed on the assessment of the measurement model. This phase is critical in determining the validity and reliability of the measurement indicators. Such thorough evaluation is crucial to ensure that the indicators accurately represent their intended constructs.

This study employs data analysis techniques using SmartPLS, which involves three evaluation stages to assess the measurement model: Convergent Validity, Discriminant Validity, and Composite Reliability.

The reflection size is considered substantial if the component score has a correlation of greater than 0.6 with the construct. The measurement model's validity is assessed through factor loading, specifically by examining the convergent validity values of the indicators within the model. The results from the Smart PLS analysis, including outer loadings and cross-loadings, were evaluated. A total of 9 indicators were tested using a sample size of 176. The outer loading results are deemed acceptable when they exceed the threshold of 0.7 [31].

The results of the outer loadings test in this study, as shown in Table 1, indicate that the indicators have outer loadings values > 0.7, namely CP, CID, ROA, ROE, PBV, and Tobin's Q, which means that the

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convergent validity is acceptable and can be considered valid. Meanwhile, the indicators with outer loadings values < 0.7, namely ROS, PER, and EPS, were eliminated from the constructs of this study.

Table 1. Result Of Outer Loadings

Item	Loadings
Firm Value	
PER	-0.093
EPS	-0.102
PBV	0.938
Tobin's Q	0.924
Financial Performance	
ROA	0.891
ROE	0.853
ROS	0.398
Carbon Performance	
CP	1.000
Carbon Information Disclosure	
CID	1.000

Source: Processed data, 2024

Table 2 presents the results of the outer loading analysis after eliminating invalid constructs. All indicators can be considered valid following the removal and recalculation in the model, as they now meet the criteria for convergent validity. This is demonstrated by outer loading values greater than 0.70 for each indicator.

Table 2. Valid Outer Loading Results

Item	Loadings
Firm Value	
PBV	0.938
Tobin's Q	0.926
Financial Performance	
ROA	0.867
ROE	0.891
Carbon Performance	
CP	1.000
Carbon Information Disclosure	
CID	1.000

Source: Processed data, 2024

Based on Table 3 the results of cross loading can be seen that the expected value of any of the latent variable has the highest loading value with other loading values for other latent variables, which are the loading values of each indicator of a latent variable that has the greatest value. Therefore, the conclusion is that the cross-load value is acceptable.

Table 3. Result of Cross Loading

Description	FV	FP	CP	CID
PBV	0.938	0.589	0.440	0.168
Tobin's Q	0.926	0.526	0.435	0.136
ROA	0.532	0.867	0.295	0.128
ROE	0.523	0.891	0.411	0.157

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CP	0.469	0.405	1.000	0.121
CID	0.164	0.163	0.121	1.000

Source: Processed data, 2024

Discriminant Validity

To establish discriminant validity, the square root of the AVE (Average Variance Extracted) should be compared with the correlation values between latent variables. Discriminant validity is considered to be present if the square root of the AVE exceeds these correlation values. Additionally, an AVE value greater than 0.5 is necessary to affirm discriminant validity [31] .

Based on Table 4, the AVE (Average Variance Extracted) values are all above 0.5, ranging from 0.772 to 1.000. The highest AVE value is observed in CP and CID at 1.000, while the lowest is in FP at 0.0.772. Additionally, the square roots of the AVE values, which range from 0.879 to 1.000, are higher than the corresponding correlation values between the latent variables. The highest square root of the AVE is 1.000 for CP and CID, and the lowest is 0.879 for FP. Therefore, it can be concluded that the variables in this study meet the criteria for discriminant validity

Table 4. Result of Average Variance Extracted (AVE)

Variable	AVE	√AVE
FV	0.868	0.932
FP	0.772	0.879
CP	1.000	1.000
CID	1.000	1.000

Source: Processed data, 2024

Composite Reliability

A total of 6 indicators will be tested using 176 samples. Composite reliability is considered acceptable if the value exceeds 0.7 [31], as shown in Table 5.

Table 5. Result of Composite Reliability

Variable	Composite Reliability
FV	0.930
FP	0.871
CP	1.000
CID	1.000

Source: Processed data, 2024

Based on the testing results presented in Table 5, it can be observed that the composite reliability for all constructs exceeds 0.70. This indicates that the constructs meet the required reliability criteria.

After the initial analyses, the study focuses on the inner model, examining the relationships between latent constructs. The aim is to understand these connections and ensure the model's overall structure is consistent and coherent. The evaluation of the inner model follows the outer model testing. This analysis assesses the relationships between variables and determines whether there are positive or negative effects. The inner model evaluation is based on two criteria: the R^2 value of the endogenous latent variable and the estimation of the path coefficients [31].

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Inner Model (Structural Model)

The R^2 value indicates how well exogenous variables can measure and explain endogenous variables. According to [30], an R^2 value close to 1 suggests that the exogenous variables have a strong capacity to explain or predict the endogenous variables. The R^2 values are typically categorized as follows: 0.75 indicates a strong explanatory power, 0.50 indicates a moderate explanatory power, and 0.25 indicates a weak explanatory power.

Table 6. R Square

Variable	R Square
FV	0.423
FP	0.177

Source: Processed data, 2024

Based on Table 6, the R^2 results indicate that the FV construct has the highest R^2 value at 0.423, while the FP construct has the lowest at 0.177. Consequently, it can be concluded that the R^2 values are not strong enough to robustly explain the two endogenous variables.

The results of the PLS Algorithm testing are presented below (Figure 2), followed by the results after eliminating invalid indicators (Figure 3), the bootstrap testing (Figure 4). Figure 2 displays the initial assessment of the outer model, indicating the presence of invalid indicators with outer loadings values < 0.7.

Figure 3 presents the reassessment of the outer model following the elimination of invalid indicators. This evaluation encompasses convergent validity, discriminant validity, and reliability. It specifically verifies the extent to which indicators correlate within a construct (convergent validity), the distinctiveness of the constructs from one another (discriminant validity), and the consistency of the indicators in measuring their respective constructs (reliability).

Figure 4 presents the model tested using bootstrapping. This bootstrap validation is part of the inner model examination, which focuses on the relationships between constructs rather than the relationships between indicators and constructs. Essentially, it assesses whether the hypothesized structural model relationships are statistically significant.

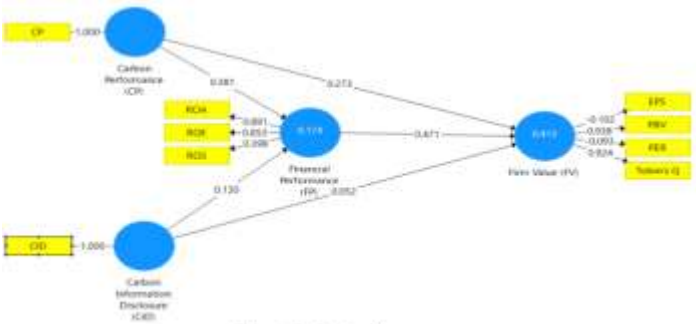

Figure 2. PLS algorithm

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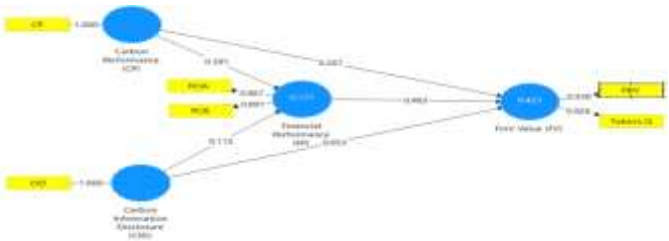

Figure 3. PLS algorithm results after the removal of invalid indicators

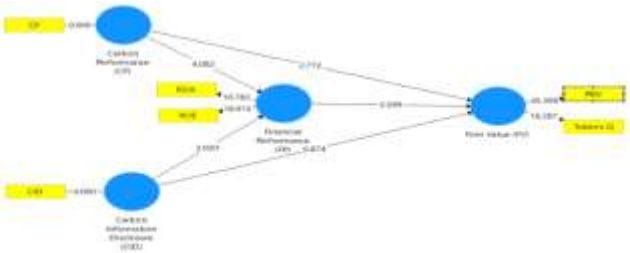

Figure 4. Inner model

Hypothesis testing results are deemed significant if the p-value is less than 0.05 and the test statistic exceeds 1.96. Details of the hypothesis testing results are provided in Table 6 for direct effects and Table 7 for total indirect effects.

Table 7. Inner Model (Path Coefficients)

Variable	Original Sample (O)	T-Statistics (O/STDEV)	P-Values	Significant
CP → FP	0.391	4.082	0.000	Supported
CP → FV	0.267	2.772	0.006	Supported
CID→ FP	0.115	2.020	0.044	Supported
CID→FV	0.053	0.874	0.383	Rejected
FP →FV	0.483	3.599	0.000	Supported

Source: Processed data, 2024

Based on Table 7 of the Inner Model, carbon performance has a positive influence on financial performance. The results of the original sample value were 0.391, the mean sample results were 0.391 and the standard deviation results were 0.096, indicating that there was a positive and acceptable relationship between carbon performance and financial performance. Then the value of the T statistic is 4.082, this value is greater than the table t of 1.96 and the p value is 0,000 (<0.05).

The hypothesis that carbon performance positively influences firm value is supported. The original sample value is 0.267, the mean sample value is 0.256, and the standard deviation is 0.096. These results indicate a positive and significant relationship. The T-statistic is 2.772, which exceeds the critical value of 1.96, and the p-value is 0.006 (<0.05), confirming the hypothesis's statistical significance

The hypothesis that carbon information disclosure positively influences financial performance is supported. The original sample value is 0.115, with a mean sample value of 0.109 and a standard deviation of 0.057. These results indicate a positive and acceptable relationship carbon information disclosure and financial performance. The T-statistic value is 2.020, which exceeds the critical value of 1.96, and the p-value is 0.044 (<0.05), indicating statistical significance.

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The hypothesis that carbon information disclosure has a positive effect on firm value is not supported. The original sample value is 0.053, the mean sample value is 0.052, and the standard deviation is 0.061, indicating a positive but weak relationship. The T-statistic is 0.874, which is less than the critical value of 1.96, and the p-value is 0.383 (>0.05), indicating that the relationship is not statistically significant.

The hypothesis that financial performance positively influences firm value is supported. The original sample value is 0.483, the mean sample value is 0.472, and the standard deviation is 0.134. These results indicate a positive and significant relationship between financial performance and firm value. The T-statistic is 3.599, which exceeds the critical value of 1.96, and the p-value is 0.000 (<0.05), confirming the statistical significance of the relationship.

Table 8. Inner Model (Total Indirect Effects)

Variable	Original Sample (O)	T-Statistics (O/STDEV)	P-Values	Significant
CP→FP→FV	0.189	2.553	0.011	Supported
CID→FP→FV	0.056	1.647	0.100	Rejected

Source: Processed data, 2024

Base on table 8, the hypothesis that carbon performance positively influences firm value through mediating variable of financial performance is supported. The original sample value is 0.189, with a mean sample value of 0.188 and a standard deviation of 0.074. These results indicate a positive and acceptable relationship carbon information disclosure and financial performance. The T-statistic value is 2.553, which exceeds the critical value of 1.96, and the p-value is 0.011 (<0.05), indicating statistical significance

The hypothesis that carbon information disclosure has a positive effect on firm value through mediating variable of financial performance is not supported. The original sample value is 0.056, the mean sample value is 0.053, and the standard deviation is 0.034, indicating a positive but weak relationship. The T-statistic is 1.647, which is less than the critical value of 1.96, and the p-value is 0.100 (>0.05), indicating that the relationship is not statistically significant.

Discussion

The hypothesis testing in this study was conducted to observe the significance values obtained from the structural model analysis described above. The hypothesis testing involved four variables: two independent variables (carbon performance and carbon information disclosure), one mediating variable (financial performance), and one dependent variable (firm value). After data processing, it was found that the first, second, third, fifth, and sixth hypotheses were significant, while the fourth and seventh hypotheses were not significant.

Measurement The Effect of Carbon Information Disclosure on Financial Performance

The research shows that carbon performance has a significant positive impact on the financial performance of companies listed on the Indonesia Stock Exchange (IDX) during the period 2020-2022, as indicated by ROA and ROE metrics. This means that companies that are better at managing their carbon emissions tend to demonstrate better financial performance. Positive carbon performance reflects higher operational efficiency, innovation in energy use, and effective environmental risk management, which in turn boosts investor confidence and reduces operational costs and legal risks. Thus, a company's efforts to reduce its carbon footprint not only contribute to environmental sustainability but also provide economic benefits through increased profitability and return on equity. This finding underscores the importance of sustainability strategies and environmental responsibility as key factors in business and investment decision-making. This study is supported by previous research conducted by [3], [5], [21], and [32] which found that carbon performance can enhance financial performance. However, it contrasts with the study by [17], which found that carbon performance does not affect operational performance.

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The Effect of Carbon Performance on Firm Value

The research demonstrates that carbon performance has a significant positive impact on firm value, as measured by Price-to-Book Value (PBV) and Tobin's Q metrics. This suggests that companies that actively manage and improve their carbon performance such as reducing carbon emissions and adopting sustainable practices—are perceived as more valuable in the market. This perception may be driven by several factors, including increased investor confidence, lower operational risks, and potential cost savings from improved efficiency. Additionally, companies with strong carbon performance may be better positioned to comply with environmental regulations and avoid potential fines or sanctions. The positive relationship between carbon performance and firm value highlights the importance of integrating environmental sustainability into corporate strategies, as it not only benefits the environment but also enhances the company's financial health and market valuation. The findings of this study are supported by previous research conducted by by [3], [14], [20], [26], [27] and [28] which found that carbon performance affects firm value. However, these findings are not consistent with the studies conducted by [33] and [17], which stated that carbon performance does not affect firm value when measured by Tobin's Q.

The Effect of Carbon Information Disclosure on Financial Performance

The research shows that carbon information disclosure has a significantly positive impact on financial performance, as indicated by ROA and ROE metrics. This means that companies that are more transparent in disclosing information related to carbon emission management have better financial performance. Detailed and accurate carbon information disclosure can enhance investor and stakeholder trust, as it demonstrates the company's commitment to sustainable business practices and social responsibility. [34] This transparency can reduce reputational and legal risks related to environmental impact, thereby enabling the company to gain greater trust from investors, customers, and the public. Moreover, good carbon information disclosure can also drive operational efficiency, reduce energy costs, and improve resource management effectiveness. All these factors contribute to increased company profitability and, ultimately, better financial performance, as reflected in higher ROA and ROE. Thus, the findings of this study underscore the importance of transparent carbon management and information disclosure as key factors in enhancing a company's financial performance. The results of this study are consistent with previous research conducted by [16], [5], [27], and [3] which found that carbon information disclosure has a positive impact on financial performance. However, they are not in line with the findings of [18], who stated that carbon information disclosure does not affect financial performance. Meanwhile, [35] and [36] found that carbon information disclosure negatively affects financial performance.

The Effect of Carbon Information Disclosure on Firm Value

The research shows that carbon information disclosure has a positive, yet not significant, impact on firm value as measured by Price-to-Book Value (PBV) and Tobin's Q indicators on the Indonesia Stock Exchange during the period 2020-2022. Although carbon information disclosure can demonstrate a company's commitment to sustainability and environmental responsibility, which should theoretically enhance firm value perceptions, the effect is not strong enough to be significantly reflected in the PBV and Tobin's Q metrics. This is due to various factors, including a lack of investor awareness regarding the importance of carbon disclosure or because the disclosures are not detailed and comprehensive enough to significantly influence investment decisions. Additionally, external factors such as market conditions or insufficient regulations may also impact these results. These findings highlight that while transparency in carbon disclosure is important, companies need to improve the quality and depth of the information they provide to significantly affect firm value in the market. The results of this study are consistent with the research conducted by [33], which found that carbon information disclosure does not affect firm value. In contrast, studies by [16] , [5], [27], and [3], indicate that carbon information disclosure has a significant positive impact on firm value. However, [35] and [37] found that the relationship between carbon information disclosure and firm value is a significant negative impact.

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The Effect of Financial Performance on Firm Value

The research findings indicate that financial performance has a significant positive impact on firm value, as measured by the Market Book Ratio (MBR) and Tobin's Q for companies listed on the Indonesia Stock Exchange during the period 2020-2022. This can be explained by financial theory, which asserts that good financial performance reflects operational efficiency, high profitability, and effective risk management, all of which contribute to an increase in firm value. Strong financial performance enhances investor and stakeholder confidence, which in turn increases demand for the company's shares and elevates the market value relative to its book value, as reflected in the MBR and Tobin's Q ratios. When a company demonstrates positive and stable financial performance, investors are more likely to view it as a better investment opportunity, which is then reflected in the increased market value of the firm. This study confirms this theoretical relationship, where solid financial performance not only boosts internal profitability but also sends a strong signal to the market about the company's health and future prospects, thereby enhancing the overall firm value. The results of this study are consistent with previous research conducted by [38], which found that financial performance, as proxied by ROA, ROE, and ROI, has a significant positive impact on firm value measured by Tobin's Q. Similarly, [39] found that ROA, ROE, and ROI have a significant positive effect on firm value as measured by Tobin's Q. Additionally, [27] found that financial performance, as proxied by ROA, ROE, and ROI, has a significant positive impact on firm value with Tobin's Q as the proxy.

The Effect of Carbon Performance on Firm Value Value Through the Mediating Variable of Financial Performance.

The study results indicate that financial performance, measured by Return on Asset (ROA) and Return on Equity (ROE), mediates the significant positive influence of carbon performance on firm value, measured by Price Book Vakue (PBV) and Tobin's Q, in companies listed on the Indonesia Stock Exchange during the period 2020-2022. This suggests that companies with good carbon performance, i.e., those effective in managing their carbon emissions, tend to show better financial performance, which in turn increases firm value. In other words, the positive impact of carbon performance on firm value occurs through the increase in ROE. However, the study also found that the direct relationship between carbon performance and firm value, whether measured by PBV and Tobin's Q, is not significant. This means that carbon performance alone is not sufficient to directly increase firm value without an improvement in financial performance. These results highlight the importance of financial performance as a critical pathway through which carbon performance can affect firm value. [40] Sustainability strategies focusing on improving carbon performance need to be accompanied by efforts to enhance financial performance to have a significant impact on firm value.

These results confirm corporate finance theory according to [24], which states that good financial performance is key to increasing firm value and attracting investors. [41] Companies with good carbon performance, reflecting efforts in emission reduction and environmentally friendly practices, can improve their financial performance through increased ROA and ROE. This increase in ROA and ROE, in turn, contributes to the enhancement of firm value.

The Effect of Carbon Information Disclosure on Firm Value Value Through the Mediating Variable of Financial Performance

The study results indicate that financial performance, measured by Return on Assets (ROA) and Return on Equity (ROE), does not mediate the relationship between carbon disclosure and firm value, measured by Price Book Value (PBV) and Tobin's Q, for companies listed on the Indonesia Stock Exchange from 2020-2022. This reveals the complexity of assessing sustainability's impact on market value. Although carbon disclosure is crucial for transparency and sustainability practices, its effect on firm value is not mediated through traditional financial performance metrics like ROA and ROE. Instead, the market and investors view carbon disclosure as a commitment to long-term environmental responsibility and sustainability, enhancing reputation, reducing regulatory risk, and attracting socially responsible investments [42]. However, these benefits take longer to reflect in concrete financial performance, indicating that non-

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financial factors, such as reputation and market perception, play a significant role in determining firm value, not immediately visible through traditional financial performance.

Corporate finance [24] emphasizes that company decisions and actions, including transparency and information disclosure, should be reflected in financial performance and market valuation. However, these findings indicate that while carbon disclosure is crucial for corporate governance and environmental responsibility, its impact on firm value is not mediated by financial performance metrics like ROA and ROE. This shows that the market values carbon disclosure directly without waiting for changes in financial performance indicators. Investors and other stakeholders view carbon disclosure as a company's commitment to sustainable practices and social responsibility, which can enhance the company's reputation and reduce future environmental risk. Thus, firm value can increase through improved market trust and positive perception, even if this increase is not immediately reflected in short-term profitability or operational efficiency.

Conclusion

Carbon performance significantly positively affects both financial performance (ROA and ROE) and firm value (PBV and Tobin's Q). The study also finds that financial performance mediates the relationship between carbon performance and firm value. Effective carbon management leads to better financial outcomes, which subsequently enhance market valuations. These findings highlight the importance of integrating carbon management into business strategies to boost both environmental and financial performance, improve investor confidence, and support long-term corporate success and sustainability.

Financial performance, measured by Return on Assets (ROA) and Return on Equity (ROE), has a significant positive impact on firm value, assessed through Price to Book Value (PBV) and Tobin's Q. The findings indicate that improvements in financial performance directly enhance firm value. This underscores the importance of strong financial performance as a key factor in increasing market valuation. In other words, companies that demonstrate strong financial performance are likely to have higher market values, reflecting investor confidence and a positive assessment of the company's profit potential and stability.

Carbon information disclosure has a significant positive impact on financial performance, as measured by Return on Assets (ROA) and Return on Equity (ROE). However, its positive effect on firm value, assessed through Price to Book Value (PBV) and Tobin's Q, is not significant. Additionally, financial performance does not mediate the relationship between carbon information disclosure and firm value. This indicates that while disclosing carbon information enhances financial metrics, it does not directly translate into increased firm value through traditional financial performance channels. The results suggest that the market may value carbon disclosure for its implications on corporate transparency and environmental responsibility, but this valuation does not immediately affect firm value or financial performance indicators. Therefore, companies should consider that while carbon information disclosure improves financial performance, its impact on firm value may require more nuanced or longer-term assessments beyond immediate financial metrics.

Limitation and Scope for Further Research

This study has several limitations. It relies on traditional financial metrics (ROA, ROE) and firm value indicators (PBV, Tobin's Q), which may not capture all aspects of carbon performance and disclosure impacts. The short-term focus may not reflect long-term effects, and findings may not be generalizable beyond the specific market studied. Additionally, the research does not differentiate between various carbon management practices, and the quality of carbon disclosure may vary among companies. Future research should explore long-term impacts of carbon performance and disclosure, use a broader range of financial and non-financial metrics, and include cross-market comparisons. Additionally, differentiating between specific carbon management strategies and assessing the quality of disclosure could provide deeper insights into their effects on firm value.

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