Formosa Journal of Multidisciplinary Research (FJMR)
Vol. 4, No. 6, 2025: 2691-2710

The Effect of Carbon Emissions Disclosure on Firm Value with Managerial Ownership as a Moderating Variable in Energy Sector Companies Listed on the IDX in 2020-2022

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A R T I C L E I N F O
Keywords: Carbon Emission Disclosure, Firm Value, Managerial Ownership, Corporate Governance, Sustainability

Received : 16, May
Revised : 30, May
Accepted: 23, June

A B S T R A C T
This study aims to investigate how carbon emission disclosure can influences the firm value, with also considering managerial ownership as a moderating variable. This research is conducted on energy sector companies listed on the Indonesia Stock Exchange from 2020 to 2022. Using panel regression analysis on 261 observations, the analysis reveals that carbon emission disclosure has a positive and statistically significant effect on firm value, suggesting that transparent environmental reporting enhances investor trust. Furthermore, managerial ownership strengthens this relationship, indicating that when managers hold equity in the firm, they are more motivated to disclose sustainability practices that support long-term value creation. The study illustrates that aligning corporate governance mechanisms with clear environmental reporting can significantly contribute to enhancing a company's market value.

DOI: https://doi.org/10.55927/fjmr.v4i6.257
ISSN-E: 2829-8896
https://npaformosapublisher.org/index.php/fjmr

INTRODUCTION

One of the strategic aspects of the environment in the business world is the development of environmentally based businesses. Companies have a responsibility to maintain environmental sustainability, but currently only a few companies care about this environmental issue. In fact, with the global trend of green investment, companies that do not care about environmental aspects will have difficulty obtaining investment funding because investors will choose companies whose businesses do not damage the environment. For example, Storebrand Asset Management ASA, the largest private investor from Norway, withdrew its investment from Brazil because it was deforesting the Amazon Forest, another example is that Swiss bank terminated funding to two Australian states after determining that their policies failed to align with climate change principles (Husaini, 2020). To promote a financial system grounded in sustainability, Indonesia introduced Financial Services Authority Regulation *(Otoritas Jasa Keuangan)* No. 51/POJK.03/2017 in 2017, which mandates the integration of sustainable finance practices across financial institutions, issuers, and public companies. This regulation reflects the understanding that sustainable development requires an economic model that equally emphasizes environmental stewardship, social responsibility, and economic growth. Thus, companies will have a responsibility to maintain environmental sustainability.

Moreover, to ensure the long-term sustainability of business operations, companies must adopt the Triple Bottom Line approach, which emphasizes three key dimensions: profit (economic), people (social), and planet (environmental). The profit dimension represents the conventional financial aspect of business, encompassing revenue generation, profitability, and economic growth—essential components for a company's survival and development. The people dimension focuses on social responsibility, including labor practices, employee rights, customer satisfaction, and the company's role in enhancing the welfare of surrounding communities through Corporate Social Responsibility (CSR) initiatives. The planet dimension assesses the company's environmental footprint, covering its strategies and actions in environmental preservation, energy efficiency, and efforts to minimize adverse ecological impacts.

The issue of climate change is currently a global topic of discussion, especially because of the significant impact of carbon emissions on the environment (IPCC, 2021). Firms operating within the energy sector are frequently identified as key sources of carbon emissions, thereby attracting significant attention from stakeholders including regulatory authorities, investors, and society at large. Carbon emissions are an important instrument for companies to demonstrate their commitment and seriousness towards sustainability and increase transparency and accountability.

Although regulations and pressure from stakeholders encourage companies to disclose carbon emissions transparently, existing practices still do not meet expectations. In Indonesia, especially in energy sector companies listed on the IDX, there is a mismatch between the information expected by investors and the public and the reality of disclosure that occurs (Rahmawati, 2019). This

indicates a gap between stakeholder demands and the Company's internal practices in conveying environmental information more comprehensively.

A number of prior studies have explored how environmental information disclosure affects firm value, study by (Rahmanita S., 2020) found that both carbon emission disclosure and environmental performance exert a significant positive impact on a company's value. Research was also conducted by (Kurnia, Nur, & Putra, 2021) which examines the effect of carbon emission disclosure on company value in manufacturing sector companies in Indonesia and Australia, the results show that carbon emission disclosure in Indonesia increases company value, while this does not happen in Australia because its implementation is considered expensive and requires large costs.

Managerial ownership refers to share ownership by management or internal companies, this can be one of the benchmarks of good corporate governance because it can align the interests of management and shareholders and reduce agency conflicts. In relation to carbon emission disclosure, managerial ownership can strengthen the positive impact of such disclosure. The role of company management can influence the direction of a company's environmental policy, managerial ownership is believed to be able to influence decision making related to information disclosure, considering that management who owns company shares tend to have incentives to increase transparency in order to maintain the company's reputation and value (Sari & Nugroho, 2020).

Nevertheless, existing research presents varying conclusions regarding the influence of carbon emission disclosure on firm value. While several studies report a positive association, (Agustina, 2020) found no significant impact of carbon emission disclosure on firm value. Other research, such as that by (Rahmanita SA, 2020) and (Bana, 2022) highlights that in Indonesia, carbon emission disclosure remains largely voluntary and has yet to be implemented comprehensively by companies. These inconsistencies present a research gap that calls for further investigation into the interplay between carbon emission disclosure, managerial ownership, and firm value.

The novelty of this analysis is the more specific focus on carbon emission disclosure, where previous studies more generally discuss environmental issue disclosure, this study specifically examines carbon emission disclosure which is the main indicator of environmental impact. This study also focuses on energy sector companies because these companies are often accused of being one of the main contributors to carbon emissions. This study refines previous research by introducing managerial ownership, as a proxy for corporate governance, as a moderating variable influencing the effect of carbon emission disclosure on firm value.

Building upon the aforementioned background, this study is intended to, among other objectives, examine the impact of carbon emission disclosure on firm value in energy sector companies listed on the Indonesia Stock Exchange during the 2020–2022 period. Additionally, it aims to evaluate the moderating effect of managerial ownership on the relationship between them. In addition, this research is expected to provide empirical contributions that can be used as a reference for companies in improving the quality and transparency of carbon

emission information disclosure and in designing ownership structure management strategies that can support increasing company value.

The objectives to be achieved through this research include:

1) To examine and evaluate how the disclosure of carbon emission influences firm value within the corporate context
2) To examine and evaluate how the managerial ownership influences the strength of relationship between carbon emission disclosure and firm value.

LITERATURE REVIEW

Carbon Emissions

Carbon emissions refer to the discharge of carbon dioxide (CO_2) into the atmosphere, primarily resulting from the combustion of fossil fuels such as coal, petroleum, and natural gas. These emissions are recognized as a major driver of the greenhouse effect, which in turn accelerates global warming and contributes to climate change. The disclosure of carbon emissions constitutes a crucial element of a company's corporate social responsibility (CSR) initiatives in response to climate issues. This disclosure represents the firm's commitment to transparency regarding the carbon footprint produced by its operations. In such reports, companies typically disclose quantitative data on emissions along with the actions undertaken to mitigate them, thereby providing stakeholders with insight into the environmental consequences of their activities and the strategies employed to address them.

Company Values

Evaluating a company serves as a key step in ensuring its long-term sustainability (going concern) since the assessment of the company is able to provide investors with an overview in order to invest their capital, thus the company's credibility can be maintained (Pratomo, 2021).

The primary objective of a company's establishment is to enhance shareholder wealth by increasing the firm value. This value is commonly reflected through the company's stock price in the capital market (Kinekes, 2019). Firm value, often equated with share price, represents investors' perceptions of the company's performance and prospects. A rising stock price indicates a higher firm value, which in turn contributes to greater prosperity for its shareholders (Yulianto & Widyasari, 2020).

Good Corporate Governance (GCG)

The concept of good corporate governance gained prominence following its introduction in the 1992 Cadbury Report in the United Kingdom. It was described as a framework for guiding and regulating corporate activities, wherein the responsibility for governance lies primarily with the board of directors. Shareholders refer to the board and auditors and assure themselves that the corporate governance structure is appropriate. The board's responsibility is to set the company's strategic objectives, provide leadership to implement them, oversee and report to shareholders.

Managerial Ownership

The Board of Directors in accordance with Law No. 40 of 2007 is defined as a company organ that has full authority and responsibility for the management and administration of the company in accordance with the company's objectives. The board also serves as the legal representative of the company, both within and outside the courtroom. In a company, share ownership can also be owned by the management, in this case the directors and managers. This managerial ownership is a form of internal governance that aims to reduce agency conflicts between management and shareholders, for example misuse of company assets or suboptimal decision making. Managerial share ownership is considered an effective mechanism to align the interests of managers with those of shareholders. It refers to the proportion of a company's shares held by members of management, including directors and top executives. This ownership can be quantified using the following formula (Morck, Shleifer & Vishny, 1988):

$$Managerial\ Ownership\ (\%) = \frac{Shares\ owned\ by\ management}{Total\ shares\ outstanding} \times 100$$

Theoretical Framework

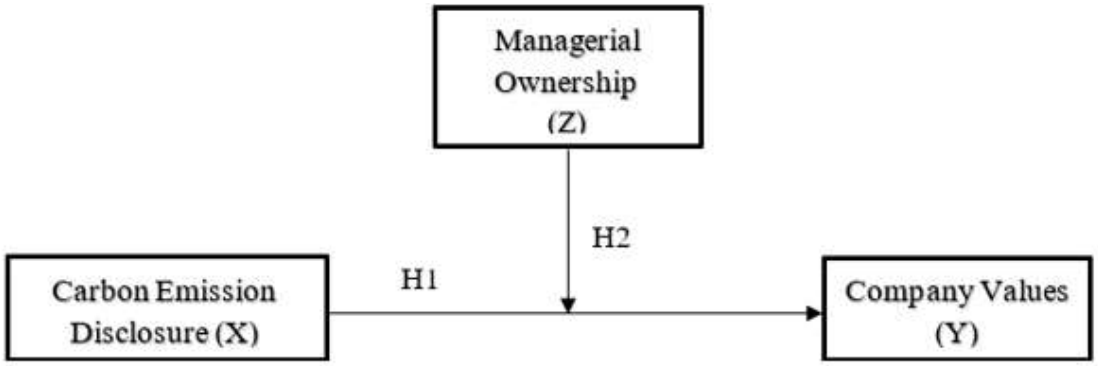

Figure 1. Theoretical Framework

Research Hypothesis

The Impact of Carbon Emission Disclosure on Company Value

Several studies related to carbon emission disclosure have demonstrated its influence on firm value. (Rahmanita S., 2020) concluded that both carbon emission disclosure and environmental performance positively affect firm value, suggesting that these factors serve as valuable signals for enhancing a company's market worth. In Similar, (Satria, 2020) found that carbon emission disclosure significantly contributes to firm value, as the information disclosed can enhance a company's reputation and stakeholder trust. Furthermore, research by (Kurnia, Nur, & Putra, 2021) indicated that in Indonesia, carbon disclosures lead to increased firm value by offering a competitive advantage but in contrast, in Australia, the same disclosure showed no effect, as it is perceived as costly and less beneficial. Based on these findings, the following hypothesis is proposed:

H1: Carbon Emission Disclosure has a positive effect on Company Value

The Moderating Effect of Managerial Ownership on the Relationship between Carbon Emission Disclosure and Firm Value

Study (Sukmawati & Henny, 2024) regarding managerial ownership having a positive influence on carbon emission disclosure, it states that managers act as controllers to increase carbon emission disclosure, decision making involves management ownership, one of which is by disclosing information regarding carbon emission disclosure to improve the firm's strategic capabilities and governance quality.

Managerial ownership is also believed to be able to escalate the firm value in accordance with Agency Theory, where the behavioral interests of the principal or shareholders who have given authority to the agency or management as decision makers to act and make decisions according to common interests and goals, the greater the portion of managerial ownership, the more active management will tend to be in maximizing the value of the company (Gunawan, Abbas, & Aulia, 2024).

In this study, the author intends to test the role of managerial ownership as a mediating variable in the relation between carbon emission disclosure and firm value. Based on this framework, propose the following hypothesis:
H2: Managerial ownership moderates or strengthens the influence of the connection between carbon disclosure practices on firm value.

METHODOLOGY

Firm Value (Y) serves as the dependent variable, while Carbon Emission Disclosure (X) is the independent variable. Managerial Ownership (Z), acting as the moderating variable, is represented by the proportion of shares owned by management. The unit of analysis comprises energy sector companies listed on the Indonesia Stock Exchange (IDX) that have consistently published both financial statements and sustainability reports during the 2020–2022 period. The study population includes all energy sector firms on the IDX that made their annual or sustainability reports publicly accessible via either their official websites or the IDX portal within the specified timeframe.

In this study, the entire population will be used as a research sample considering that the number of energy sector companies above is only 87 companies so that the entire population is taken for a period of 3 years (2020-2022), so that the amount of data to be used is 261 data which is expected to be able to represent the availability of data in this analysis. The study relies on secondary data, specifically drawn from financial and sustainability report that disclose from selected firms. For the purpose of data analysis, a panel regression model is applied.

RESEARCH RESULT AND DISCUSSION

Descriptive Statistical Analysis

Table 1. Descriptive Analysis Results

Date: 02/08/25 Time: 17:10
Sample: 2020 2022

	X	Z	Y	X_Z
Mean	0.135444	3.993623	1.854678	0.851903
Median	0.000000	0.000000	0.724837	0.000000
Maximum	0.861111	67.40000	25.91670	44.92500
Minimum	0.000000	0.000000	0.000000	0.000000
Std. Dev.	0.232160	12.63376	3.575632	4.334655
Skewness	1.522962	3.754808	3.898745	6.834367
Kurtosis	4.035397	16.37014	19.75304	56.20958
Jarque-Bera	111.2593	2527.916	3670.750	32444.51
Probability	0.000000	0.000000	0.000000	0.000000
Sum	34.94444	1030.355	478.5070	219.7911

Source: Data processed with Eviews 12 (2025)

Based on Table 1, the average value for Carbon Emission Disclosure (X) is 0.1354, which indicates that in general the level of carbon emission disclosure by companies in the sample is still low. This indicates that the majority of companies in this study have not actively reported their carbon emissions or have only disclosed a small part of the relevant information related to their sustainability policies. With a median of 0.0000, it can be concluded that most companies in the sample do not make any disclosures at all, and only a few consistently report their carbon emission data.

Classical Assumption Test of Equation 1 (Without Moderation)

a. Normality Test

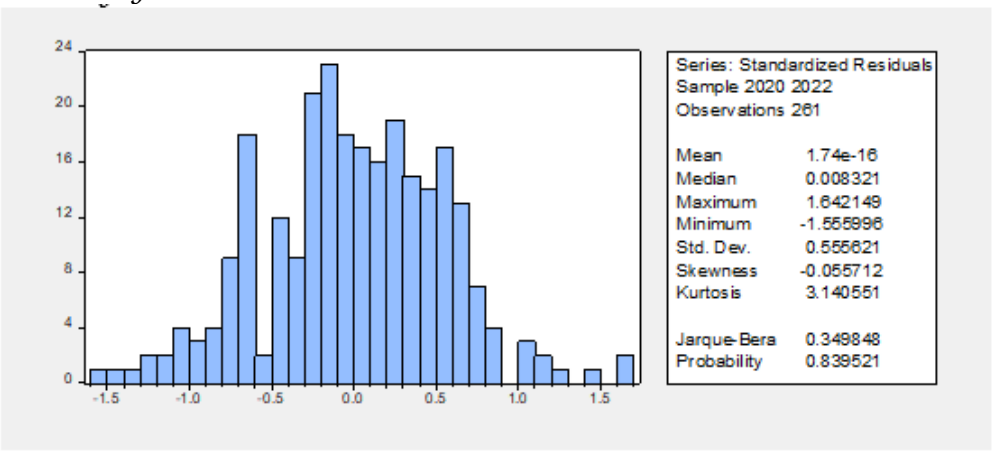

Figure 2 Results of Normality Test of Regression Equation I
Source: Data processed with Eviews 12 (2025)

Based on the results of the normality test on Regression Equation I, the histogram shows a residual distribution pattern that approaches a bell-shaped curve, which is a characteristic of a normal distribution. The skewness value of 0.055712 indicates that the residual distribution is relatively symmetrical and does not skew significantly to the right or left. In addition, the kurtosis value of 3.140551 is very close to the kurtosis value of the normal distribution (3.00), which indicates that the residual distribution is neither too sharp nor flat.

b. Multicollinearity Test

Variance Inflation Factors
Date: 05/11/25 Time: 19:12
Sample: 1 261
Included observations: 261

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
X	0.022627	1.352498	1.011914
Z	7.67E-06	1.112133	1.011914
C	0.001670	1.400709	NA

Figure 3 Multicollinearity Test Results for Regression Equation I
Source: Data processed with Eviews 12 (2025)

Multicollinearity test on Regression Equation I reveals that the centered VIF values for variables X and Z are both 1.011914, while the uncentered VIF values are 1.352498 for X and 1.112133 for Z, respectively. For variable C, the uncentered VIF value is 1.400709, but the centered VIF value is not available (NA) because it is a constant variable. All VIF values obtained are still far below the general threshold of 10, indicating that there is no significant multicollinearity problem in this regression model.

c. Heteroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	0.714221	Prob. F(3,254)	0.5443
Obs*R-squared	2.158201	Prob. Chi-Square(3)	0.5402
Scaled explained SS	2.066098	Prob. Chi-Square(3)	0.5588

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/11/25 Time: 19:17
Sample: 1 261
Included observations: 261

Figure 4. Results of Heteroscedasticity Test of Regression Equation I
Source: Data processed with Eviews 12 (2025)

The results of the heteroscedasticity test for Regression Equation I indicate an F-statistic of 0.714221 with a probability value of 0.5443, and an Obs*R-squared statistic of 2.158021 with a probability of 0.5402. Furthermore, the Scaled Explained SS test yields a probability of 0.5568. Since all probability values exceed the 0.05 significance threshold, there is no sufficient evidence to reject the null hypothesis, which implies that the variance of the residuals is constant thus satisfying the assumption of homoscedasticity.

d. Autocorrelation Test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	1.731271	Prob. F(2,256)	0.1791
Obs*R-squared	3.483059	Prob. Chi-Square(2)	0.1753

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/11/25 Time: 19:13
Sample: 1 261
Included observations: 261
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	0.022843	0.150549	0.151730	0.8795
Z	0.000300	0.002801	0.107203	0.9147
C	-0.004404	0.040881	-0.107736	0.9143
RESID(-1)	0.109994	0.062857	1.755478	0.0804
RESID(-2)	0.027224	0.063535	0.428485	0.6687

R-squared	0.013345	Mean dependent var	-3.38E-16
Adjusted R-squared	-0.002071	S.D. dependent var	0.555621
S.E. of regression	0.556196	Akaike info criterion	1.683580
Sum squared resid	79.19472	Schwarz criterion	1.751886
Log likelihood	-214.7072	Hannan-Quinn criter.	1.711029
F-statistic	0.865636	Durbin-Watson stat	1.995733
Prob(F-statistic)	0.485102		

Figure 5. Autocorrelation Test Results for Regression Equation I
Source: Data processed with Eviews 12 (2025)

The results of the autocorrelation test for Regression Equation I, conducted using the Breusch-Godfrey Serial Correlation LM Test, show an F-statistic of 1.731271 with a probability of 0.179126, and an Obs*R-squared value of 3.483059 with a probability of 0.175252. Since both probability values surpass the 0.05 significance level, there is no statistical basis to reject the null hypothesis, implying that serial correlation is not present up to the second lag in this regression equation. Thus, it can be concluded that the residuals of the regression model do not show a systematic relationship pattern between periods, so that the model meets the classical assumption of being free from autocorrelation. This strengthens the validity of the regression estimation results and allows the analysis to be continued without additional adjustments related to autocorrelation.

Panel Data Regression Model Selection Test Equation 1 (Without Moderation)

a. Chow Test Panel Data Regression Equation 1

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	1.320599	(86,172)	0.0633
Cross-section Chi-square	132.326507	86	0.0010

Cross-section fixed effects test equation:
Dependent Variable: Y
Method: Panel Least Squares
Date: 05/11/25 Time: 19:23
Sample: 2020 2022
Periods included: 3
Cross-sections included: 87
Total panel (balanced) observations: 261

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	0.609798	0.150424	4.053866	0.0001
Z	0.068254	0.002769	24.65207	0.0000
C	0.652059	0.040861	15.95798	0.0000

R-squared	0.716963	Mean dependent var	1.003180
Adjusted R-squared	0.714769	S.D. dependent var	1.044376
S.E. of regression	0.557771	Akaike info criterion	1.681690
Sum squared resid	80.26587	Schwarz criterion	1.722661
Log likelihood	-216.4605	Hannan-Quinn criter.	1.698159
F-statistic	326.7704	Durbin-Watson stat	1.674762
Prob(F-statistic)	0.000000		

Figure 6. Chow Test Results for Regression Equation I
Source: Data processed with Eviews 12 (2025)

The results of the Chow Test (Redundant Fixed Effects Test) for Regression Equation I reveal a Cross-section F statistic of 1.320599 with a probability of 0.0633, and a Cross-section Chi-square value of 132.326507 with a probability of 0.0010. Based on the decision-making criteria, the probability value of the Cross-section F, being above the 0.05 threshold, suggests insufficient

evidence to reject the Common Effect Model (CEM). However, the significantly low probability of the Cross-section Chi-square (less than 0.05) indicates that the Fixed Effect Model (FEM) may be more suitable, as it better captures the heterogeneity across entities.

b. Hausman Test Panel Data Regression Equation 1

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	3.506518	2	0.1732

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
X	1.222186	0.639743	0.097272	0.0618
Z	0.066298	0.068164	0.000058	0.8072

Cross-section random effects test equation:
Dependent Variable: Y
Method: Panel Least Squares
Date: 05/11/25 Time: 19:25
Sample: 2020 2022
Periods included: 3
Cross-sections included: 87
Total panel (balanced) observations: 261

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.577756	0.064260	8.990939	0.0000
X	1.222186	0.350296	3.489007	0.0006
Z	0.066298	0.008201	8.084499	0.0000

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.829526	Mean dependent var	1.003180
Adjusted R-squared	0.742307	S.D. dependent var	1.044376
S.E. of regression	0.530161	Akaike info criterion	1.833695
Sum squared resid	48.34421	Schwarz criterion	3.049183
Log likelihood	-150.2972	Hannan-Quinn criter.	2.322282
F-statistic	9.510840	Durbin-Watson stat	2.757170
Prob(F-statistic)	0.000000		

Figure 7 Hausman Test Results for Regression Equation I
Source: Data processed with Eviews 12 (2025)

The results of the Hausman specification test applied to Regression Equation I report a Chi-square statistic of 3.506518 with 2 degrees of freedom and an associated probability of 0.1732. As the probability exceeds the 0.05 threshold, the null hypothesis (H_0) cannot be rejected, validating the use of the Random Effect Model (REM) in this analysis. Acceptance of the null hypothesis indicates that the estimations from FEM and REM are statistically consistent, and that the individual-specific effects are assumed to be exogenous with respect to the explanatory variables.

c. LM Test Panel Data Regression Equation

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	1.687690 (0.1939)	0.008947 (0.9246)	1.696638 (0.1927)
Honda	1.299111 (0.0970)	0.094591 (0.4623)	0.985496 (0.1622)
King-Wu	1.299111 (0.0970)	0.094591 (0.4623)	0.289358 (0.3862)
Standardized Honda	1.469446 (0.0709)	0.632836 (0.2634)	-5.894246 (1.0000)
Standardized King-Wu	1.469446 (0.0709)	0.632836 (0.2634)	-2.124377 (0.9832)
Gourieroux, et al.	--	--	1.696638 (0.2034)

Figure 8 LM Test Results for Regression Equation I
Source: Data processed with Eviews 12 (2025)

Based on the results of the Lagrange Multiplier (LM Test) on Regression Equation I, the Breusch-Pagan value for the cross-section effect is 1.687690 with a probability of 0.1939, for the time effect it is 0.008947 with a probability of 0.9246, and overall (both) it is 1.696638 with a probability of 0.1927. Since all probability values are greater than the significance level of 0.05. These results support the acceptance of the null hypothesis, suggesting that random effects are not statistically significant. Therefore, the Random Effect Model (REM) is applied.

d. Panel Data Regression Model Selection Decision Equation 1

Table 2. Regression Selection Decision Table 1

Test	Model Criteria	Null Hypothesis	Test Results	Decision
Chow	FEM versus CEM	CEM is more suitable than FEM	Probability 0.0633 (Probability < 0.05 / Null Hypothesis Rejected)	CEM is more appropriate
Houseman	REM versus FEM	REM is more suitable than FEM	Probability 0.1732 (Probability > 0.05 / Null Hypothesis Not Rejected)	REM is more appropriate
Lagrange Multiplier (LM)	REM versus CEM	CEM is more suitable than REM	Probability 0.1939 (Probability > 0.05 / Null Hypothesis Not Rejected)	REM is more appropriate

Based on the outcomes of the three model selection tests, the Random Effect Model (REM) was determined to be the most appropriate approach for panel data analysis in this study. The Chow test results suggest that the Common Effect Model (CEM) is preferable to the Fixed Effect Model (FEM), while the Hausman test supports the use of REM over FEM. Additionally, the Lagrange Multiplier (LM) test indicates that REM is more suitable than CEM. Considering the combined findings from these tests, REM is regarded as the most efficient model for estimating the relationship between Carbon Emission Disclosure (X), Managerial Ownership (Z), and Firm Value (Y).

Selected Panel Data Regression Model Test Equation 1 (Without Moderation)

$$Y_{it} = \beta 0 + \beta 1 X_{it} + \beta 2 Z_{it} + \mu_i + \varepsilon_{it}$$

$$Y_{it} = 0.648 + 0.639 + 0.068 + \mu_i + \varepsilon_{it}$$

Dependent variable: Y
Method: Panel Least Squares
Date: 05/11/25 Time: 19:22
Sample: 2020 2022
Periods included: 3
Cross-sections included: 87
Total panel (balanced) observations: 261

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	0.609798	0.150424	4.053866	0.0001
Z	0.068254	0.002769	24.65207	0.0000
C	0.652059	0.040861	15.95798	0.0000

R-squared	0.716963	Mean dependent var	1.003180
Adjusted R-squared	0.714769	S.D. dependent var	1.044376
S.E. of regression	0.557771	Akaike info criterion	1.681690
Sum squared resid	80.26587	Schwarz criterion	1.722661
Log likelihood	-216.4605	Hannan-Quinn criter.	1.698159
F-statistic	326.7704	Durbin-Watson stat	1.674762
Prob(F-statistic)	0.000000		

Figure 9. Panel Data Regression Test Results Regression Equation I
Source: Data processed with Eviews 12 (2025)

The table of analysis results using the REM First Equation provides an overview of the relationship between the independent variable Carbon Emission Disclosure (X) and the dependent variable Company Value (Y). REM was chosen based on the results of previous tests, because this model is more appropriate than the FEM and CEM in the panel data analysis that applied in this research. This model assumes that there are no specific differences between entities that must be modeled with fixed effects or random effects, so that all data is analyzed collectively without considering variations between companies.

Classical Assumption Test of Equation 2 (With Moderation)

a. Normality Test

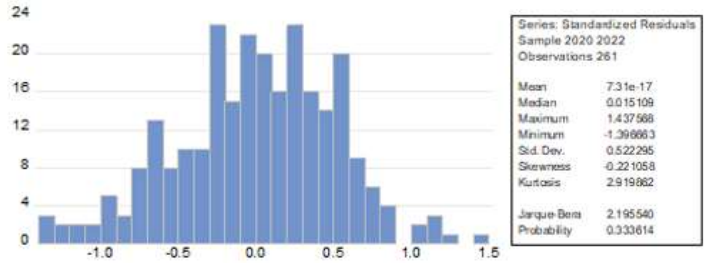

Figure 10 Results of Normality Test of Regression Equation II

Source: Data processed with Eviews 12 (2025)

According to the findings from the normality test conducted on Regression Equation II, the Skewness value of -0.221058 indicates that the residual distribution is slightly skewed to the left, but still close to symmetrical. The kurtosis value of 2.919862 indicates that the residual distribution has a shape that is close to the standard normal distribution (kurtosis = 3), which means there are no extreme deviations in the data distribution.

b. Multicollinearity Test

Variance Inflation Factors
Date: 05/11/25 Time: 19:30
Sample: 1 261
Included observations: 261

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
X	0.021868	1.473527	1.102466
Z	1.44E-05	2.361148	2.148376
X_Z	0.000131	2.384629	2.296630
C	0.001529	1.446257	NA

Figure 11. Results of Multicollinearity Test of Regression Equation II

Source: Data processed with Eviews 12 (2025)

Based on the results of the multicollinearity test in Regression Equation II, the centered VIF value for variable X is 1.102466, variable Z is 2.148376, and the interaction variable X_Z is 2.296630. All of these VIF values are far below the general threshold of 10, there is no indication of serious multicollinearity in this model. The relatively low VIF value indicates that there is no high linear correlation between the independent variables, so that each variable can be interpreted independently within the regression framework.

c. Heteroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey
Null hypothesis: Homoskedasticity

F-statistic	0.714221	Prob. F(3,254)	0.5443
Obs*R-squared	2.158201	Prob. Chi-Square(3)	0.5402
Scaled explained SS	2.066098	Prob. Chi-Square(3)	0.5588

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/11/25 Time: 19:32
Sample: 1 261
Included observations: 261

Figure 12. Results of Heteroscedasticity Test of Regression Equation II
Source: Data processed with Eviews 12 (2025)

The heteroscedasticity test results indicate an F-statistic of 0.714221 with a probability value of 0.5443, and an Obs*R-squared value of 2.158521 with a probability of 0.5402. Additionally, the Scaled Explained SS statistic is 2.068098 with a probability of 0.5568. Since all probability values exceed the 5% significance level (0.05), the null hypothesis (H_0) cannot be rejected. Therefore, it can be concluded that this regression model does not suffer from heteroscedasticity issues.

d. Autocorrelation Test

Breusch-Godfrey Serial Correlation LM Test:
Null hypothesis: No serial correlation at up to 2 lags

F-statistic	0.334569	Prob. F(2,255)	0.7160
Obs*R-squared	0.683091	Prob. Chi-Square(2)	0.7107

Test Equation:
Dependent Variable: RESID
Method: Least Squares
Date: 05/11/25 Time: 19:31
Sample: 1 261
Included observations: 261
Presample missing value lagged residuals set to zero.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	0.002477	0.148837	0.016644	0.9867
Z	-0.000221	0.003879	-0.057076	0.9545
X_Z	9.30E-06	0.011713	0.000794	0.9994
C	0.000522	0.039293	0.013278	0.9894
RESID(-1)	0.042659	0.063135	0.675675	0.4999
RESID(-2)	-0.030572	0.063754	-0.479523	0.6320

R-squared	0.002617	Mean dependent var	-1.87E-16
Adjusted R-squared	-0.016939	S.D. dependent var	0.522295
S.E. of regression	0.526701	Akaike info criterion	1.578351
Sum squared resid	70.74044	Schwarz criterion	1.660294
Log likelihood	-199.9748	Hannan-Quinn criter.	1.611289
F-statistic	0.133828	Durbin-Watson stat	2.004957
Prob(F-statistic)	0.984460		

Figure 13. Autocorrelation Test Results of Regression Equation II
Source: Data processed with Eviews 12 (2025)

The results of the autocorrelation test for Regression Equation II show an F-statistic of 0.334569 with a probability value of 0.7160, and an Obs*R-squared of 0.683091 with a probability of 0.7107. As both probability values exceed the 5% significance level, there is no sufficient evidence to reject the null hypothesis, which suggests the absence of autocorrelation (serial correlation) in the model up to the second lag. Therefore, residuals of the regression model do not show a systematic relationship pattern between periods, so that the model meets the classical assumption of being free from autocorrelation. This strengthens the validity of the regression estimation results and allows the analysis to be continued without additional adjustments related to autocorrelation.

Panel Data Regression Model Selection Test Equation 2 (With Moderation)

a. Chow Test Panel Data Regression Equation 2

Redundant Fixed Effects Tests
Equation: Untitled
Test cross-section fixed effects

Effects Test	Statistic	d.f.	Prob.
Cross-section F	1.013283	(86,171)	0.4637
Cross-section Chi-square	107.492212	86	0.0583

Cross-section fixed effects test equation:
Dependent Variable: Y
Method: Panel Least Squares
Date: 05/11/25 Time: 19:27
Sample: 2020 2022
Periods included: 3
Cross-sections included: 87
Total panel (balanced) observations: 261

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	0.363248	0.147879	2.456377	0.0147
Z	0.052178	0.003800	13.73232	0.0000
X_Z	0.066632	0.011454	5.817449	0.0000
C	0.692432	0.039106	17.70673	0.0000

R-squared	0.749897	Mean dependent var	1.003180
Adjusted R-squared	0.746978	S.D. dependent var	1.044376
S.E. of regression	0.525335	Akaike info criterion	1.565646
Sum squared resid	70.92606	Schwarz criterion	1.620275
Log likelihood	-200.3168	Hannan-Quinn criter.	1.587605
F-statistic	256.8592	Durbin-Watson stat	1.837042
Prob(F-statistic)	0.000000		

Figure 14. Chow Test Results for Regression Equation II
Source: Data processed with Eviews 12 (2025)

The results of the Chow Test for Regression Equation II show a Cross-section F value of 1.013283 with a probability of 0.4637, and a Cross-section Chi-square statistic of 107.492212 with a probability of 0.0583. Since both probability values exceed the 5% significance level, the null hypothesis (H_0) cannot be rejected. This indicates that there is insufficient evidence to conclude that the Common Effect Model (CEM) outperforms the Fixed Effect Model (FEM). As a result, the FEM is deemed more suitable for use in this analysis.

b. Hausman Test Panel Data Regression Equation 2

Correlated Random Effects - Hausman Test
Equation: Untitled
Test cross-section random effects

Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	6.198913	3	0.1023

** WARNING: estimated cross-section random effects variance is zero.

Cross-section random effects test comparisons:

Variable	Fixed	Random	Var(Diff.)	Prob.
X	0.855573	0.363248	0.125312	0.1643
Z	0.061142	0.052178	0.000057	0.2340
X_Z	0.037958	0.066632	0.000160	0.0235

Cross-section random effects test equation:
Dependent Variable: Y
Method: Panel Least Squares
Date: 05/11/25 Time: 19:28
Sample: 2020 2022
Periods included: 3
Cross-sections included: 87
Total panel (balanced) observations: 261

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.615249	0.065729	9.360358	0.0000
X	0.855573	0.383515	2.230870	0.0270
Z	0.061142	0.008432	7.250720	0.0000
X_Z	0.037958	0.017055	2.225637	0.0273

Effects Specification

Cross-section fixed (dummy variables)

R-squared	0.834326	Mean dependent var	1.003180
Adjusted R-squared	0.748097	S.D. dependent var	1.044376
S.E. of regression	0.524171	Akaike info criterion	1.812802
Sum squared resid	46.98322	Schwarz criterion	3.041947
Log likelihood	-146.5707	Hannan-Quinn criter.	2.306879
F-statistic	9.675786	Durbin-Watson stat	2.752357
Prob(F-statistic)	0.000000		

Figure 15. Hausman Test Results for Regression Equation II
Source: Data processed with Eviews 12 (2025)

The results of the Hausman Test for Regression Equation II indicate a Chi-square statistic of 6. 198913 with a probability of 0.1023. Since this

probability exceeds the 5% significance level (0.05), the null hypothesis (H_0) cannot be rejected. This implies that the Random Effect Model (REM) is more appropriate than the Fixed Effect Model (FEM) for this analysis. In other words, there is insufficient evidence to state the existence of a correlation between the entity-specific effect and the independent variable.

c. LM Test Panel Data Regression Equation 2

Lagrange Multiplier Tests for Random Effects
Null hypotheses: No effects
Alternative hypotheses: Two-sided (Breusch-Pagan) and one-sided (all others) alternatives

	Test Hypothesis		
	Cross-section	Time	Both
Breusch-Pagan	0.057896 (0.8099)	0.038203 (0.8450)	0.096099 (0.7566)
Honda	-0.240616 (0.5951)	-0.195456 (0.5775)	-0.308350 (0.6211)
King-Wu	-0.240616 (0.5951)	-0.195456 (0.5775)	-0.229497 (0.5908)
Standardized Honda	-0.062623 (0.5250)	0.271991 (0.3928)	-7.351396 (1.0000)
Standardized King-Wu	-0.062623 (0.5250)	0.271991 (0.3928)	-2.763502 (0.9971)
Gourieroux, et al.	--	--	0.000000 (1.0000)

Figure 16. LM Test Results for Regression Equation II
Source: Data processed with Eviews 12 (2025)

The Lagrange Multiplier (LM) Test results for Regression Equation II indicate a Breusch-Pagan statistic of 0.057896 for the cross-section with a probability of 0.8099, and a value of 0.096099 for the combined effect with a probability of 0.7566. Since both probability values exceed the 5% significance threshold, the null hypothesis (H_0) cannot be rejected. This suggests that there is no significant random effect present in the model. Therefore, the Common Effect Model (CEM) is considered more appropriate than the Random Effect Model (REM) for this analysis.

d. Panel Data Regression Model Selection Decision Equation 2

Table 3. Regression Selection Decision Table II

Test	Model Criteria	Null Hypothesis	Test Results	Decision
Chow	FEM versus CEM	CEM is more suitable than FEM	Probability 0.4637 (Probability > 0.05/ Null Hypothesis Not Rejected)	FEM is more appropriate
Houseman	REM versus FEM	REM is more suitable than FEM	Probability 0.1023 (Probability > 0.05 / Null Hypothesis Not Rejected)	REM is more appropriate
Lagrange Multiplier (LM)	REM versus CEM	CEM is more suitable than REM	Probability 0.8099 (Probability > 0.05 / Null Hypothesis Not Rejected)	REM is more appropriate

Based on the results of these three tests, REM was chosen as the best model for panel data analysis in this study. REM provides more efficient

estimation by considering random effects between entities, while the Hausman test confirms that the assumption of random effects being uncorrelated with the independent variables holds true, thereby validating the use of a consistent and reliable model. This conclusion is further reinforced by the LM test, which indicates that random effects significantly contribute to the variation within the panel data structure.

Selected Panel Data Regression Model Test Equation 2 (With Moderation)

Dependent Variable: Y
Method: Panel Least Squares
Date: 02/08/25 Time: 16:54
Sample: 2020 2022
Periods included: 3
Cross-sections included: 86
Total panel (balanced) observations: 258

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	0.341628	0.147505	2.316048	0.0214
Z	0.051867	0.003785	13.70398	0.0000
X_Z	0.067240	0.011405	5.895762	0.0000
C	0.704137	0.039256	17.93716	0.0000

R-squared	0.752388	Mean dependent var	1.014845
Adjusted R-squared	0.749464	S.D. dependent var	1.044782
S.E. of regression	0.522951	Akaike info criterion	1.556725
Sum squared resid	69.46336	Schwarz criterion	1.611809
Log likelihood	-196.8175	Hannan-Quinn criter.	1.578874
F-statistic	257.2666	Durbin-Watson stat	1.877087
Prob(F-statistic)	0.000000		

Dependent Variable: Y
Method: Panel EGLS (Cross-section random effects)
Date: 05/11/25 Time: 19:27
Sample: 2020 2022
Periods included: 3
Cross-sections included: 87
Total panel (balanced) observations: 261
Swamy and Arora estimator of component variances

Variable	Coefficient	Std. Error	t-Statistic	Prob.
X	0.363248	0.147552	2.461830	0.0145
Z	0.052178	0.003791	13.76280	0.0000
X_Z	0.066632	0.011428	5.830363	0.0000
C	0.692432	0.039019	17.74603	0.0000

Effects Specification	S.D.	Rho
Cross-section random	0.000000	0.0000
Idiosyncratic random	0.524171	1.0000

Weighted Statistics

R-squared	0.749897	Mean dependent var	1.003180
Adjusted R-squared	0.746978	S.D. dependent var	1.044376
S.E. of regression	0.525335	Sum squared resid	70.92606
F-statistic	256.8592	Durbin-Watson stat	1.837042
Prob(F-statistic)	0.000000		

Unweighted Statistics

R-squared	0.749897	Mean dependent var	1.003180
Sum squared resid	70.92606	Durbin-Watson stat	1.837042

Figure 17. Panel Data Regression Test Results Regression Equation II
Source: Data processed with Eviews 12 (2025)

The table of analysis results using REM provides an overview relationship between the independent variables Debt Default (DD), Opinion Shopping (OS), and Financial Distress (FD) to the dependent variable Audit Tenure (AT). REM was selected based on the outcomes of the preceding tests, as it effectively accounts for random variations across entities within the panel data structure. This table presents the values of the regression coefficients, standard errors, t-statistics, probabilities, and the results of the F test and R-squared values. Weighted statistics are used for the main interpretation, because they are more relevant in the analysis using the REM method.

Hypothesis Testing

Table 4. Hypothesis Test Results

Hypothesis	Statement of Relationship Between Variables	Coefficient	t-Statistics	p-Value	Decision
H1	Disclosure of Carbon Emissions (X) has a positive effect on Company Value (Y)	0.363248	2.461830	0.0145	Accepted
H2	Managerial Ownership (Z) moderates Carbon Emission Disclosure (X) and Firm Value (Y) (X × Z)	0.066632	5.830363	0.0000	Accepted
	Managerial Ownership (Z) has a direct effect on Company Value (Y)	0.052178	13.76280	0.0000	Accepted
R^2 Before Moderation	Variation in Company Value (Y) that can be explained by X and Z without moderation	0.716963	-	-	-
R^2 After Moderation	Variation in Firm Value (Y) that can be explained after including the moderation interaction X × Z	0.749897	-	-	-

The results of the partial test (t-test) show that the first hypothesis (H1) is supported, with a coefficient of 0.363248, a t-statistic of 2.461830, and a probability value of 0.0145. These findings suggest that Carbon Emission Disclosure (X) has a positive and statistically significant influence on Firm Value (Y). In other words, greater transparency in disclosing carbon emissions is associated with higher firm value in the market. Such transparency enhances investor and stakeholder confidence, which ultimately contributes positively to the company's valuation.

The second hypothesis (H2) is also supported, demonstrating that Managerial Ownership (Z) moderates the relationship between Carbon Emission Disclosure (X) and Firm Value (Y). The interaction term coefficient (X × Z) is 0.066632, with a t-statistic of 5.830363 and a probability value of 0.0000, indicating that Managerial Ownership significantly strengthens the influence of carbon emission disclosure on firm value. This suggests that firms with higher levels of managerial ownership are more capable of effectively implementing transparent carbon emission reporting, which in turn enhances their market value.

CONCLUSIONS AND RECOMMENDATIONS

Conclusion

The objective of this research is to explore the impact of Carbon Emission Disclosure (X) on Firm Value (Y) and to investigate whether Managerial Ownership (Z) moderates this relationship. Drawing upon the findings from the statistical tests, the study arrives at the following conclusions:

1. Carbon Emission Disclosure (X) exerts a positive and significant influence on Firm Value (Y). This result indicates that a higher level of carbon emission transparency associated with an increase in firm value. This indicates that transparency in carbon emission reporting can increase investor and stakeholder trust, which leading to improved market perception and an increase in the firm’s financial worth.

2. Managerial Ownership (Z) plays a moderating role in the linkage between Disclosure of Carbon Emissions (X) and Company Value (Y). High managerial ownership is likely to reduce the level of managerial opportunism because managers will feel the direct impact of every decision that will be accepted by shareholders so that managers who also act as shareholders will consistently motivated to enhance the firm value to create prosperity for themselves, one of which is regarding the carbon emission disclosure policy produced by the company.

Recommendation

According to the results derived from the analysis, there are several recommendations that can be given to various interested parties, both academics, companies, and investors.

a) Further research is suggested to consider other variables that may influence the relationship between Carbon Emission Disclosure (X) and Firm Value (Y), such as Environmental Performance, Corporate Social Responsibility (CSR), or Firm Size. In addition, research can be conducted with a cross-country analysis approach to understand how sustainability policies and corporate governance moderate this relationship across different regulatory environments and country conditions.
b) For companies, it is expected to increasingly consider sustainability aspects, especially carbon emission disclosure and corporate governance implementation in investment decision making. Companies that demonstrate greater transparency in carbon emission reporting and uphold strong governance practices tend to achieve higher firm value and experience reduced long-term risk.
c) It is advisable for investors to adopt a more prudent approach in evaluating potential investment opportunities, especially by analyzing the company's financial condition and paying attention to audit opinions as one of the important indicators. Comprehensive fundamental and technical analysis is needed to reduce investment risk.

ADVANCED RESEARCH

This study has several limitations that need to be considered in interpreting the results. One of the main limitations is the scope of the industrial sectors used, where this study only focuses on certain companies. This may limit the generalization of the findings to other sectors that may have different sustainability characteristics. Therefore, further research is advised to expand the sample to include various industrial sectors that have varying levels of carbon emissions and governance.

In addition to the limited scope, this study also faces obstacles in obtaining carbon emission disclosure data which is still voluntary in several companies. Not all companies consistently disclose their carbon emission data, which can affect the accuracy of the analysis. To overcome this, future research can use additional data sources such as sustainability reports, interviews with management, or more extensive secondary data analysis.

Subsequent research is encouraged to explore a wider range of moderating or mediating variables, including environmental performance, corporate social responsibility, and firm size, to deepen the understanding of how carbon emission disclosure impacts firm value. In addition, research can be conducted with a cross-country analysis approach to understand how sustainability policies and corporate governance moderate this relationship across different regulatory environments and country conditions.

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