The Effect of Carbon Emission on Company Performance with Financial Slack as a Moderation Variable in Mining and Energy Sector Companies in Indonesia (2021-2025)

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Abstract.
This study examines the effect of Carbon Emission Scope 1 and Carbon Emission Scope 2 on company performance and investigates the moderating role of Financial Slack. This study employed a quantitative approach using secondary data from the annual reports and sustainability reports of mining and energy companies listed in Indonesia during the 2021–2025 period. The sample was selected using purposive sampling, resulting in 42 companies (210 firm-year observations). Panel data regression analysis was conducted using the Fixed Effect Model (FEM). The results indicate that Carbon Emission Scope 1 has a positive and significant effect on company performance, while Carbon Emission Scope 2 has a negative and significant effect. Furthermore, Financial Slack significantly moderates the relationship between carbon emissions and company performance by weakening the effect of Carbon Emission Scope 1 and strengthening the effect of Carbon Emission Scope 2. These findings suggest that the impact of carbon emissions on company performance varies according to the type of emissions and that financial flexibility plays an important role in supporting sustainable corporate performance.

Keywords: *Carbon Emission Scope 1, Carbon Emission Scope 2, Financial Slack and Company Performance.*

I. INTRODUCTION

In an era of increasingly competitive business competition, company performance is one of the aspects that determine the success and sustainability of a company. The company's ability to maintain optimal performance not only reflects the effectiveness of its resource management, but also shows the company's ability to create value for shareholders, attract investors, and increase competitiveness in the midst of economic dynamics (Estébanez & Martín, 2025). Efforts to improve and maintain company performance are the main goals that every company continues to strive for (Farida & Setiawan, 2022).

Company performance is also a widely used indicator to assess the success of business strategies implemented by companies. Companies with good performance generally have a higher ability to generate profits, manage assets efficiently, fulfill obligations to stakeholders, and create sustainable growth (Handoyo, Suharman, Ghani, & Soedarsono, 2023). However, the company's performance achievement is not only influenced by internal factors such as resource management and management policies, but also by various changes in external conditions that require the company to

continue to adapt in order to remain able to maintain a competitive advantage (Cheraghalizadeh, Olya, & Tumer, 2021).

Climate change has become one of the global challenges that is increasingly affecting various aspects of economic, social, and environmental development. Increasing concentrations of greenhouse gases, particularly carbon dioxide (CO_2), have prompted many countries to implement various emission control policies, such as *Carbon Tax*, *Emissions trading system*, as well as environmental reporting obligations as part of a commitment to sustainable development (Kumar et al., 2025). Companies are no longer only required to generate profits, but are also responsible for managing the environmental impact arising from their operational activities (Satoto, 2024). Carbon emission management has become an increasingly important issue as stakeholders demand greater corporate accountability and transparency regarding environmental impacts (I. F. S. Wahyuningrum et al., 2026).

The mining and energy sector is one of the sectors with the highest carbon emission intensity because its operational activities depend on the use of fossil energy, exploration processes, production, and distribution of natural resources. This is consistent with (I. F. Wahyuningrum, et al., 2026), who highlighted that manufacturing and mining companies are environmentally sensitive industries that face increasing demands for environmental transparency and accountability. In Indonesia, the sector has a significant contribution to national economic growth, but it also faces increasing pressure from governments, investors, and the public to reduce carbon emissions and support the transition to a low-carbon economy. This condition makes the management of carbon emissions a strategic issue that has the potential to affect the Company's sustainability and performance (Zain, Patunru, & Hartono, 2025).

Various studies have examined the relationship between *carbon emissions* and company performance, but they still produce mixed findings. Ganda and Milondzo (2018) found that companies that implement green investments to reduce carbon emissions are able to improve financial performance. Ferrat (2021), Miah et al. (2021), and Liu et al. (2023) show that carbon emissions negatively affect company performance because they increase compliance costs, regulatory risks, and pressure from stakeholders. In contrast, Senna and Moxotó (2025) and Almonares et al. (2026) found that companies with higher levels of carbon emissions actually have better financial performance, especially those measured using *Return on Assets (ROA)* and *Return on Equity (ROE)*. Mendieta-Callirgos et al.'s (2026) research also shows that the influence of carbon emissions on a company's performance is influenced by the existence of *financial slack*, while Kayser et al. (2026) prove that the reduction of *Scope 1* and *Scope 2 emissions* is positively correlated with an improvement in the company's financial performance.

One of the factors that is thought to be able to explain the relationship is *Financial Slack*. Based on perspective *Resource-Based View* (RBV), *Financial Slack* It is a strategic resource that provides financial flexibility for companies to invest in low-

carbon technologies, improve energy efficiency, and meet various environmental regulatory demands without disrupting the company's operational activities. Thus, availability *Financial Slack* is estimated to be able to strengthen or weaken the influence of carbon emissions on the Company's performance (Dewi, Hilal, & Rosilawati, 2026).

Although research on carbon emissions has developed quite rapidly, research that specifically distinguishes the effects of *Scope 1 emissions* and *Scope 2 emissions* on company performance is still relatively limited, especially in companies in the mining and energy sectors in Indonesia. In addition, research that examines the role *of financial slack* as a moderation variable in the relationship is also still rare. Therefore, this study aims to analyze the influence of *Scope 1 and Scope 2 carbon emissions on company performance and test whether* financial slack is able to moderate the relationship in mining and energy sector companies registered in Indonesia during the 2021–2025 period. The results of this research are expected to contribute to the development of literature on corporate performance and sustainability, as well as provide input for companies, investors, and regulators in formulating effective carbon emission management strategies.

Carbon emission Scope 1 is a greenhouse gas emission that comes directly from the company's operational activities, such as the process of burning fuel, the use of production machinery, and operational vehicles. In mining and energy companies, high Scope 1 emissions reflect the large environmental impact caused by the company's activities. Based on *Legitimacy Theory*, companies are required to carry out activities that are in accordance with the values and expectations of society in order to gain and maintain social legitimacy. High carbon emissions have the potential to increase pressure from regulators, investors, and the public, so that companies must incur greater costs to meet environmental regulations, low-carbon technology investments, and emission management. This condition can reduce operational efficiency and have an impact on declining company performance. On the other hand, companies that are able to effectively control Scope 1 emissions will gain the trust of stakeholders, improve the company's reputation, and create a competitive advantage that has a positive impact on the company's performance. Research by Ferrat (2021), Miah et al. (2021), Liu et al. (2023), and Wendy et al. (2026) shows that carbon emissions have a negative effect on company performance. Based on this description, the hypothesis proposed is:

H1: Carbon Emission Scope 1 has a negative effect on the Company's Performance.

Carbon emissions Scope 2 are indirect emissions that come from the consumption of electricity, heat, or energy purchased by companies. Although not generated directly from the production process, Scope 2 emissions still reflect the company's energy efficiency level. Based on *Stakeholder Theory*, companies are required to meet the expectations of stakeholders through responsible environmental management,

including energy use efficiency. High Scope 2 emissions indicate high energy consumption which can increase operational costs and affect investors' perception of the company's commitment to running a sustainable business. On the other hand, companies that are able to manage energy consumption efficiently will benefit in the form of cost savings, increased reputation, and increased investor confidence so that they can improve company performance. Research by Kayser et al. (2026) shows that a decrease in Scope 2 emissions is positively correlated with an increase in company performance, while Liu et al. (2023) and Ferrat (2021) show that high carbon emissions negatively impact company performance. Based on this description, the hypothesis proposed is:

H2: Carbon Emission Scope 2 has a negative effect on the Company's Performance.

Based on *the Resource-Based View (RBV), financial slack* is a strategic resource that provides financial flexibility for companies to support various long-term investments. Companies that have a high *financial slack* will be better able to finance investments in low-carbon technologies, improve energy efficiency, meet environmental regulations, and develop innovations that support carbon emission reduction. Thus, the cost pressure due to high Scope 1 emissions can be minimized so that the negative impact of carbon emissions on the company's performance is smaller. On the other hand, companies with low *financial slack* will experience limitations in funding environmental investments, making them more vulnerable to performance degradation when facing emission reduction pressures. Research by Mendieta-Callirgos et al. (2026) shows that *financial slack* strengthens the relationship between carbon emissions and company performance. Therefore, the hypothesis proposed is:

H3: Financial Slack moderates the influence of Carbon Emission Scope 1 on Company Performance.

From a *Resource-Based View (RBV)* perspective, companies with *larger financial slack* have the ability to invest in energy-saving technologies, the use of renewable energy, and various innovations that are able to reduce Scope 2 emissions without disrupting the company's operational activities. The availability of these financial resources allows the company to meet the demands of regulators and stakeholders while maintaining profitability and operational efficiency. On the other hand, companies with low *financial slack* will face limitations in making energy-saving investments so that the impact of Scope 2 emissions on company performance will be greater. Research by Mendieta-Callirgos et al. (2026) shows that *financial slack* is able to moderate the relationship between carbon emissions and company performance. Based on this description, the hypothesis proposed is:

H4: Financial Slack moderates the influence of Carbon Emission Scope 2 on Company Performance.

II. METHODS

This study uses a quantitative approach with a causal associative research design to examine the influence of *Scope 1 and Scope 2 carbon emissions on company performance and the role of* financial slack as a moderation variable. The data used is secondary data obtained from the *annual reports* and *sustainability reports* of companies in the mining and energy sector in Indonesia during the 2021-2025 period. The report is obtained through the official website of each company as well as other official publication sources.

This study uses a quantitative approach with a causal associative research design to test the influence of *Scope 1 and Scope 2 carbon emissions on the performance of companies with* financial slack as a moderation variable. The data used is secondary data obtained from the *annual reports* and *sustainability reports* of mining and energy sector companies listed on the Indonesia Stock Exchange for the period 2021–2025. The research sample was determined using *a purposive sampling* technique based on certain criteria as presented in Table 1.

Table 1. Sample Selection Criteria

NO	Criteria	Total
1	Energy sector companies listed on the Indonesia Stock Exchange (IDX) during the period 2021–2025	92
2	Energy sector companies that do not publish *annual reports* and/or *sustainability reports* during the 2021–2025 period	(50)
	Total sample companies	**42**
	Total analysis units (42 companies × 5 years)	**210**

Source : IDX data processed (2026)

After determining the research sample, the operational definition of each research variable is presented to explain the measurement, indicators, and data sources used in this study. The operationalization of variables ensures that each construct is measured consistently and objectively based on the information disclosed in the companies' annual reports and sustainability reports. The operational definitions of the variables are presented in Table 2.

Tabel 2. Operational Variables

No	Variable	Definition	Indicator	Measurement
1	Company Performance (Y)	A company's ability to generate profits from its total assets	ROA	Net Profit / Total Assets
2	Carbon Emission Scope 1 (X1)	Direct greenhouse gas emissions from sources owned or controlled by the company	Total Direct CO_2e Emissions	Total Scope 1 Emissions from the Sustainability Report/GHG Emissions Report (metric tons of CO_2e)

3	Carbon Emission Scope 2 (X2)	Indirect greenhouse gas emissions from the electricity purchased and consumed by the company	Total Indirect CO_2e Emissions from Energy	Total Scope 2 Emissions from the Sustainability Report/GHG Emissions Report (metric tons of CO_2e)
4	Financial Slack (Z)	The company's excess financial resources exceed its minimum operational needs	Current Ratio	Current Assets / Current Liabilities

Source : Data processed from various sources, 2026

The research data was collected using a documentation method by extracting information about *Scope 1 carbon emissions*, *Scope 2 carbon emissions*, company performance, and *financial slack* from the *company's annual report* and *sustainability report*. Furthermore, the data was analyzed using panel data regression because it was able to combine *cross-section* and *time series data*, resulting in a more comprehensive estimate in testing the relationship between variables. Before the hypothesis test is carried out, the selection of the panel data regression model is carried out in stages through the Chow Test, the Hausman Test, and if necessary the Lagrange Multiplier (LM) Test. Once the best model is obtained, the analysis is followed by hypothesis testing to assess the direct influence of *Scope 1 and Scope 2 carbon emissions on company performance as well as the influence of* financial slack moderation.

III. RESULT AND DISCUSSION

Panel Data Regression Model Selection

The selection of the panel data regression model began with the Chow Test and continued with the Hausman Test to determine the estimation model that best suits the characteristics of the research data.

Table 3. Chow Test

Effects Test	Statistic	D.F.	Prob.
Cross-section F	6.793805	(41,165)	0.0000
Cross-section Chi-square	207.659772	41	0.0000

Source : EViews 13 output, data processed (2026)

Based on the results of the Chow Test, the probability value of Cross-section F was 0.0000 and Cross-section Chi-square was 0.0000, both of which were smaller than the significance level of 0.05 (0.0000 < 0.05). Thus, H_0 is rejected and H_1 is accepted, so that the Fixed Effect Model (FEM) is more appropriate to be used than the Common Effect Model (CEM). These results show that there are significant differences in characteristics between firms in the research sample so that an approach that

accommodates individual firms' effects is more appropriate. Next, it is necessary to perform the Hausman Test to determine whether the best model is the Fixed Effect Model (FEM) or the Random Effect Model (REM).

Table 4. Hausman Test

Test Summary	Chi-Sq. Statistic	Chi-Sq. D.F.	Prob.
Cross-section random	13.576500		30.0035

Source : EViews 13 output, data processed (2026)

Based on the results of the Hausman Test, the Chi-Square value was obtained of 13.576500 with a probability value (Prob.) of 0.0035. Since the probability value is less than 0.05 (0.0035 < 0.05), H_0 is rejected and H_1 is accepted. This shows that the Fixed Effect Model (FEM) is more appropriate than the Random Effect Model (REM). Thus, the panel data regression model chosen in this study is the Fixed Effect Model (FEM) because it is able to accommodate differences in characteristics between companies (cross-section) that affect the results of the study.

Goodness of Fit Test

The assessment of the feasibility of the regression model was carried out through the Goodness of Fit Test. These tests include the F-Test to test the significance of the model simultaneously, the t-test to test the significance of each variable partially, and the Coefficient of Determination (Adjusted R^2) to measure the model's ability to explain the variation of dependent variables.

Table 5. Test F

Effects Specification

Cross-section fixed (dummy variables)			
Root MSE	6.344875	R-squared	0.659376
Mean dependent var	13.41657	Adjusted R-squared	0.563248
S.D. dependent var	10.89737	S.E. of regression	7.201764
Akaike info criterion	6.980791	Sum squared resid	8454.062
Schwarz criterion	7.729905	Log likelihood	-685.9830
Hannan-Quinn crister.	7.283630	F-statistic	6.859412
Durbin-Watson stat	1.626793	Prob(F-statistic)	0.000000

Source : EViews 13 output, data processed (2026)

Based on the results of the F Test (simultaneous) on the Fixed Effect Model (FEM), an F-statistic value of 6.859412 was obtained with a Prob(F-statistic) value of 0.000000. Since the probability value is smaller than the significance level of 0.05 (0.000000 < 0.05), H_0 is rejected and H_1 is accepted. This shows that independent variables together (simultaneously) have a significant effect on dependent variables. Thus, the regression model used is fit to explain the relationship between independent variables and dependent variables in this study. Furthermore, to determine the influence of

each partially independent variable on the company's performance, a t-test was performed.

Table 6. T test

Effects Specification

Cross-section fixed (dummy variables)		
Root MSE	6.344875	R-squared 0.659376
Mean dependent var	13.41657	Adjusted R-squared 0.563248
S.D. dependent var	10.89737	S.E. of regression 7.201764
Akaike info criterion	6.980791	Sum squared resid 8454.062
Schwarz criterion	7.729905	Log likelihood -685.9830
Hannan-Quinn crister.	7.283630	F-statistic 6.859412
Durbin-Watson stat	1.626793	Prob(F-statistic) 0.000000

Source : EViews 13 output, data processed (2026)

Based on the test results, the Adjusted R-squared value of 0.563248 shows that the model's ability to explain the variation of dependent variables is 56.32%. This means that 56.32% of changes in dependent variables can be explained by independent variables used in the study, while the remaining 43.68% are influenced by other factors outside the research model that were not included in the analysis. Thus, the model used has a fairly good ability to explain the relationship between independent variables and dependent variables.

Hypothesis Testing

Table 7. Hypotheses 1 and 2

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	16.49507	1.260872	13.08227	0.0000
X1	8.52E-06	3.99E-06	2.138400	0.0340
X2	-1.14E-05	3.71E-06	-3.066256	0.0025
Z	-0.828457	0.517669	-1.600360	0.1114

Source : EViews 13 output, data processed (2026)

Based on the results of the t-test in Hypothesis Test Tables 1 and 2, the Carbon Emission Scope 1 (X1) variable has a probability value of 0.0340, smaller than the significance level of 0.05. Thus, H1 is accepted, which means that Carbon Emission Scope 1 has a significant effect on the company's performance. The results of the study show that Scope 1 carbon emission has a positive effect on ROA. These findings show that the higher the direct carbon emissions produced by a company, the higher the company's performance measured using Return on Assets (ROA). These results are consistent with Callirgos, et al. (2026) who also found that Scope 1 carbon emissions have a positive and significant effect on ROA in public companies in Latin America.

In addition, the variable Carbon Emission Scope 2 (X2) has a probability value of 0.0025, which is also smaller than 0.05, so H2 is accepted. This shows that Carbon

Emission Scope 2 has a significant effect on company performance. In contrast to Callirgos, et al. (2026) who did not find a significant effect of Scope 2 carbon emissions on ROA, this study shows that Scope 2 carbon emissions have a negative effect on ROA. The difference in results is suspected to be caused by differences in sample characteristics, country contexts, and company performance measurements used. In this study, company performance was only measured using ROA, while Callirgos, et al. (2026) evaluated performance using ROA, ROE, and Tobin's Q.

Table 8. Hypotheses 3 and 4

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	16.74120	1.244358	13.45368	0.0000
X1	2.74E-05	7.52E-06	3.643258	0.0004
X2	-2.92E-05	6.95E-06	-4.202073	0.0000
Z	-0.861577	0.518882	-1.660447	0.0987
INT1	-1.25E-05	4.23E-06	-2.945627	0.0037
INT2	1.18E-05	3.92E-06	3.005055	0.0031

Source : EViews 13 output, data processed (2026)

Based on the Hypothesis Test tables 3 and 4, the INT1 (Carbon Emission Scope 1 × Financial Slack interaction variable) has a probability value of 0.0037, which is smaller than the significance level of 0.05. Thus, H3 is accepted, which means that Financial Slack is able to moderate the influence of Carbon Emission Scope 1 on Company Performance (ROA). The findings indicate that companies with higher levels of financial slack tend to be able to reduce the impact of direct carbon emissions on company performance. The interaction coefficient of -1.25E-05 indicates a negative moderation direction, so the existence of Financial Slack weakens the relationship between Carbon Emission Scope 1 and Company Performance.

The INT2 (Carbon Emission Scope 2 × Financial Slack) interaction variable has a probability value of 0.0031, which is also smaller than 0.05. Thus, H4 is accepted, which means that Financial Slack is able to moderate the influence of Carbon Emission Scope 2 on Company Performance. This suggests that higher levels of liquidity magnify the influence of indirect carbon emissions on ROA. This condition indicates that companies with better short-term obligations are able to meet short-term obligations have greater flexibility in managing energy use, so that changes in Scope 2 emissions have a greater impact on the Company's performance. The interaction coefficient value of 1.18E-05 indicates a positive moderation direction, thus strengthening the relationship between Carbon Emission Scope 2 and Company Performance.

This finding is different from Callirgos, et al. (2026) who found no effect of financial slack moderation on the relationship between Scope 2 carbon emissions and company performance. The difference can be caused by several factors. First, this study used the Current Ratio as a proxy for financial slack, while Callirgos, et al.

(2026) used different financial slack measures so that the measured aspects of financial slack were not entirely the same. Second, the difference in sample characteristics between mining and energy companies in Indonesia and public companies in Latin America allows financial slack to play a different role in influencing the relationship between Scope 2 emissions and company performance. In addition, differences in energy structures, environmental policies, and pressures from stakeholders in each region can also lead to differences in empirical outcomes.

IV. CONCLUSION

This study provides empirical evidence that the relationship between carbon emissions and company performance cannot be viewed in general, but rather needs to be differentiated based on the characteristics of its emission source. In addition, the existence of Financial Slack shows that the capacity of a company's financial resources has an important role in influencing the relationship between carbon emission management and company performance. These findings indicate that environmental management strategies and financial flexibility need to be considered simultaneously to support the achievement of sustainable corporate performance.

This study enriches the literature on the relationship between carbon emissions and company performance by showing that the impact of carbon emissions differs based on the type of emissions produced and is influenced by the company's financial flexibility. These findings also provide practical implications for management in designing emissions management strategies and allocating financial resources to support the company's sustainable performance.

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