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Ecological Efficiency, Investment Opportunity Set, and Capital Structure: The Path to Sustainable Financial Performance

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Abstract: This research is motivated by the dual pressures faced by Indonesia's energy sector in balancing the acceleration of renewable energy transition with the necessity to sustain solid financial results. This research examines the influence of ecological efficiency, investment opportunity set (IOS), and capital structure on financial performance of energy sector firms listed on the Indonesia Stock Exchange (IDX) during 2022-2024. A quantitative method was applied, using panel data regression on 129 firm-year observations from 43 companies selected through purposive sampling. Based on the Chow test, Hausman test, and Lagrange Multiplier test, the Common Effect Model (CEM) emerged as the most suitable estimation approach. The findings reveal that ecological efficiency does not significantly impact financial performance within the short-term observation window of this study, as its economic benefits follow a lagging effect pattern that has yet to materialize in immediate profitability. In contrast, IOS shows a positive and significant influence on financial performance, indicating that companies with greater investment opportunities allocate resources more effectively to enhance ROA. Capital structure negatively and significantly affect financial performance, suggesting that excessive debt reliance reduces profitability due to higher interest expenses and financial risk. Simultaneously, all variables significantly influence financial performance. The findings conclude that investment decisions and capital structure management are more immediate determinants of short-term financial performance, while ecological efficiency requires a longer time horizon to generate measurable economic value.

Keywords: Ecological Efficiency; Investment Opportunity Set; Capital Structure; Financial Performance; Emission Intensity.

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1. Introduction

Climate change has become a global crisis marked by escalating environmental degradation and increasingly frequent extreme weather events that threaten economic and social stability worldwide [1] . Greenhouse gas (GHG) concentrations have reached record high levels, with global CO_2 emissions from fossil fuel combustion reaching 37.8 $GtCO_2$ in 2024 and projected to rise further in 2025 [2], [3], [4].

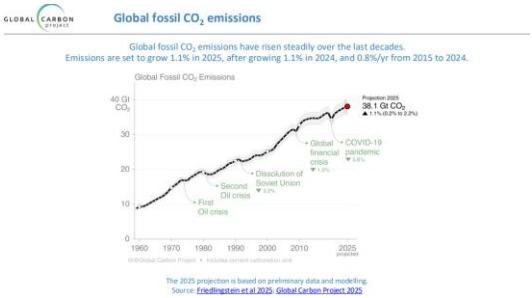

Figure 1. Trends in Global Fossil CO_2 Emissions (1960-2024)

Source: Global Carbon Project 2025

The energy sector remains the dominant contributor to this escalation, prompting international frameworks such as the Paris Agreement to dive nations toward emission reduction commitments [5], [6].

Indonesia, having produced approximately 812 million tons of CO_2 from fossil fuel combustion [3], responded to this global pressure by setting a Net Zero Emission target for 2060 through Financial Services Authority (OJK) Regulation No. 51/POJK.03/2017, which mandates the integration and disclosure of sustainability practices among listed companies. Despite this regulatory push, corporate sustainability performance in Indonesia remains relatively low compared to other countries [7], positioning energy sector companies as a strategic and policy relevant context for examining how firms balance environmental responsibility with financial viability, particularly through market based instruments such as carbon trading [8], [9].

Within this context, three firm level factors are theoretically linked to financial performance. Ecological Efficiency, grounded in the Natural Resources-Based View (NRBV) [10], reflects a firm's capacity to generate optimal economic output while minimizing resource use and environmental impact [11]. The Investment Opportunity Set (IOS), explained through Signaling Theory [12], captures a firm's growth potential as reflected in its investment and expansion decisions [13], [14], [15]. Capital Structure, informed by the Pecking Order Theory [16], reflects how financing choices affect the balance between risk and profitability, particularly as energy firms pursue capital intensive transition investments [17], [18], [19].

Prior studies examining these three factors individually report inconsistent results. Ecological efficiency has been found to have both significant positive effects in financial performance [11] and negative, insignificant effects [20], [21], [22]. Similarly, IOS has shown positive associations with financial performance in some studies [13], [23], [24], while capital structure findings range from significantly negative [25], [26] to insignificant [18], [27]. A fundamental limitation across this body of research is its tendency to examine these variables in isolation, which fails to capture how ecological efficiency, investment opportunities, and financing decisions jointly shape financial outcomes, particularly within capital intensive, high risk sectors such as energy, where these factors are inherently interdependent. This gap is further compounded by the limited number of studies that integrate environmental sustainability with investment and financing decisions within a single empirical model in developing markets such as Indonesia, which is simultaneously accelerating its energy transition and financing mounting pressure for environmental transparency [28], [29], [30].

Unlike prior studies that have predominantly examined ecological efficiency, IOS, or capital structure in isolation often within single industry or cross-sectoral samples putside the energy context. This study is the first, to the best of the author's knowledge, to simultaneously these all three variables with a unifled panel data model specific to Indonesia's energy sectors, thereby capturing their interdependent effects on financial performance during a critical period of national energy transition. To address this gap, the present study offers a novel contribution by simultaneously testing ecological efficiency, IOS, and capital structure within a single panel data model, an integrated approach that, to date, has not been applied to Indonesia's energy sector**.** This research is grounded in the Natural Resources-Based View (NRBV) [10], Signaling Theory [12], and Pecking Order Theory [16] as the theoretical foundation linking these three variables to financial performance.

This study contributes to the literature in three ways. First, it empirically fills the identified gap by integrating Ecological Efficiency, IOS, and Capital Structure into a comprehensive panel data model. Second, it provides empirical evidence from Indonesia's energy sector during its ongoing transition period, a contex that remains underrepresented in the international literature. Third, the findings offer practical implications for business management and regulators in formulating optimal financial and sustainability strategies amid the national energy transition.

2. Preliminaries or Related Work or Literature Review

2.1 Natural Resource-Based View (NRBV)

The Natural Resource-Based View (NRBV) theory was originally introduced by Stuart L. Hart [10], positioning that a company's strategy and competitive advantage are fundamentally rooted in its ability to support sustainable environmental and economic activities. Within this framework, NRBV emphasizes three core strategic capabilities: pollution prevention, product stewardship, and sustainable development. Through these capabilities, firms achieve a sustained competitive advantage by proactively minimizing negative operational impacts on the environment. Furthermore, NRBV explains that a company's long-term sustainability is highly dependent on its ability to manage ecological constraints as well as public expectations [31], [32] .

2.2 Signaling Theory

Signaling Theory [12] states that business entities use signals to convey information regarding financial prospects and growth opportunities to external entities such as investors and the public. Through financial statements, managers communicate their confidence regarding the company's future performance, investors to evaluate the firm's capacity to achive long-term goals [33] . The use of debt, for example, is viewed as a credible signal that the company possesses a solid cash flow, thereby potentially increasing stock value in the eyes of investors [34].

2.3 Pecking Order Theory

The Pecking Order Theory [35] states that business entities follow a hierarchy of preferences when determining their funding sources, starting with internal funding before turning to debt financing if needs are met, and reserving the issuance of new shares as a last resort because it is viewed as high-risk and potentially sends a negative signal to investors [16].

2.4 Ecological Efficiency

Ecological Efficiency is a concept first introduced by Dr. Stefan Schaltegger and Dr. Andreas Sturm [36] and later popularized by the World Business Council for Sustainable Development [37] through the publication Changing Course: A Global Business Perspective on Development and the Environment. This concept refers to the ability to create competitive goods and services that fulfill human wants and enhance quality of life while concurrently reducing resource consumption and environmental effects. and resource consumption throughout a product's entire life cycle. The ecological efficiency approach is viewed as a strategy that does not merely focus on environmental compliance but also has the potential to improve financial performance through resource efficiency and emissions control, which can reduce operational costs, mitigate environmental risks, and enhance investor legitimacy and trust. In operational practice, ecological efficiency reflects a balance between creating economic value; specifically measured by sales revenue and reducing ecological pressure, such as a company's efforts to reduce the use of raw materials, energy, and waste to minimize environmental impact [38].

Carbon management and disclosure practices can be explained through Stuart L. Hart's Natural Resource-Based View (NRBV) [10], ecological efficiency is viewed as part of a business entity's strategic capabilities in creating sustainable competitive advantage. The NRBV emphasizes that business entities capable of efficiently managing natural resources and reducing environmental impacts while promoting sustainable development will possess a superior competitive position [32] . Thus, ecological efficiency serves not only as an environmental management effort but also as a corporate strategy for creating sustainable economic value. In this study, ecological efficiency is proxied through the emission intensity (greenhouse gas/GHG) approach, which divides total emissions by sales revenue. A lower ecological intensity indicates a higher level of ecological efficiency [11] . Systematically, Emission Intensity can be formulated as follows:

$$\text{Emission Intensity} = \frac{\text{Metric tons of } CO^2 \text{ Emission per year}}{\text{Sales (millions of rupiah)}}$$

Greenhouse gas (GHG) emission data employed in this research were obtained from the sustainability reports that energy sector companies released to the public. Emissions measurements refer to the complete Scope 1, Scope 2, and Scope 3 emissions disclosed by these companies [39] . Meanwhile, economic value data was obtained from annual financial reports. All data was collected through the companies' official websites and secondary sources such as the Indonesia Stock Exchange (IDX).

2.5 Investment Opportunity Set (IOS)

The Investment Opportunity Set (IOS) reflects the investment opportunities a company possesses and serves as a key factor in determining growth and financial performance. The IOS reflects a company's ability to identify and capitalize on investment opportunities. Companies with a high IOS indicate broader expansion opportunities, prompting management to manage funding more strategically. This corresponds with Signaling Theory, which explains that a high IOS functions as a powerful indication to the market about the business entity's growth prospects, ultimately driving increased market confidence and financial performance [24] . Under such conditions, the company will prioritize internal funding through retained earnings, adjust its funding structure, and consider dividend policies more selectively [13], [40], [41] .

From a managerial perspective, a high IOS tends to prioritize profit reinvestment, as it is considered more efficient and does not send negative signals, unlike external financing. From an investor's perspective, the IOS acts as a primary indicator for assessing a firm's growth prospects and making investment decisions, which ultimately impacts financial performance. Companies with various investment alternatives provide management with the flexibility to select projects aligned with shareholders' long-term objectives, maximizing returns while maintaining controlled risk. This situation makes companies more likely to avoid tax avoidance practices, as productive investments are deemed more beneficial than exploiting tax loopholes [42] . The IOS is empirically linked to business's capacity to achieve a sustainable growth rate (SGR), where the effective utilization of investment opportunities and increased investor confidence such as through dividend stability can drive accelerated sustainable growth. Thus, the IOS not only represents growth opportunities but also serves as a strategic indicator in enhancing a firm's competitiveness and supporting long-term development. In this research, the IOS is quantified by the Market-to-Book Value of Assets (MBVA). This metric is classified as a price-based proxy for IOS that reflect a company's growth opportunities [43] . Systematically, MBVA can be formulated as follows:

$$\text{MBVA} = \frac{\text{Total liabilities} + (\text{outstanding share} \times \text{closing price})}{\text{Total asset}}$$

The data used to calculate the MBVA is obtained from publicly available sources. Financial data, such as total assets and total equity, is obtained from the company's annual reports, while market data, including the number of shares outstanding and the closing stock price, is obtained from capital market data or the stock exchange.

2.6 Capital Structure

Capital Structure examines how a business entity determines the composition between the use of debt and equity as sources of financing to support its operational and investment ac-

tivities [44]. This concept reflects the proportion of funding derived from these two sources in supporting the company's long-term growth. Debt encompasses both temporary and extended obligations that are utilized to support the company's resources, whereas equity consists of common stock, preferred stocks, and earning that have been retained [27] . Capital structure reflects long-term financing decisions that must be managed optimally to minimize the cost of capital and maximize corporate value. The primary theory explaining this relationship is the Pecking Order Theory, which states that a business entity will prioritize internal funding sources first, followed by debt, and finally issuing new equity or shares due to information asymmetry and because such actions are generally interpreted as a negative signal by the market [16], [45] .

In the context of corporate practice, capital structure influences a company's ability to manage investments and determine financing strategies with controlled risk. Research indicates that optimal use of debt can enhance investment opportunities and firm value, particularly when a business entity has high growth prospects [18] . However, excessive leverage also has the potential to increase financial risk and reduce profitability, making the balance between debt and equity key to determining financial performance. In line with the views of Myers and Maljuf [35] , capital structure plays a role in creating a financing mix capable of supporting value-added investments while maintaining the company's financial stability [25], [26] . In this research, the capital structure is represented by the Debt-to-Equity Ratio (DER) [44] , calculated in this manner:

$$\textbf{DER} = \frac{\textbf{Total liabilities}}{\textbf{Total equity}}$$

The data used to measure the DER was obtained from statistical reports published by the Indonesia Stock Exchange (IDX). This information, which is used to calculate the ratio, comprises details about a company's total debt and total equity.

2.7 Synthesis Of Previous Studies

To strengthen the theoretical framework and fulfill the empirical foundations of this research, Table.1 systematically summarizes and compares the key findings from previous studies on each variable. This matrix highlights the empirical consensus, conflicting results, and the research gaps addressed in this study.

Table 1. Summary of Previous Studies on Each Variable

No.	Variable	Author &Year	Underlying Theory/Context	Key Findings/Empirical Results
1.	**Ecological Efficiency**	Daud et al. (2023)	NRBV / Indonesian Listed Companies	Significant Positive Effect: Implementing eco-efficiency through carbon emission intensity significantly enhances financial performance by driving operational cost reductions.
		Czerny & Letmathe (2017)	NRBV / EU Emissions Trading Scheme (EU ETS)	Negative and Insignificant Effect: Strict compliance and internal carbon mitigation efforts inside the EU-ETS act as financial burdens, reducing short-term economic returns.
		Meutia & Kartasari (2023)	Corporate Sustainability / Indonesia	Insignificant Effect: Corporate ecological practices do not directly influence immediate financial results due to low market appreciation for green disclosures.

		Puspita & Imronudin (2024)	ESG Framework / LQ45 Companies Indonesia	Insignificant Effect: Eco-efficiency failed to show a definitive positive impact on financial performance, as market actors focus heavier on traditional financial metrics.
2.	**Investment Opportunity Set (IOS)**	Putra & Manuari (2024)	Signaling Theory / Corporate Growth	Positive Association: Higher investment opportunities yield stronger financial performance and enable flexible dividend and expansion policies.
		Hayati et al.. (2022)	Signaling Theory / Food & Beverage Sector	Positive Association: IOS positively affects financial performance, indicating that available corporate expansion opportunities serve as a strong operational catalyst.
		Hermawan et al. (2025)	Signaling Theory / Enterprise Value	Positive Association: IOS acts as a powerful market signal that directly boosts market confidence and firm value through improved financial performance
3.	**Capital Structure**	Muhammed et al. (2024)	Pecking Order Theory / Ethiopian Banks	Significantly Negative Effect: Higher dependency on external debt financing increases default risk and interest burdens, crashing overall profitability.
		Omokore et al. (2024)	Financing Decisions / Nigerian Healthcare	Significantly Negative Effect: Increased leverage structurally degrades profit margins due to high costs of capital and rigid repayment obligations.
		Anozie et al. (2023)	Trade-Off Theory / Nigerian Oil & Gas Sector	Insignificant Effect: Leverage variations do not systematically alter financial performance, as capital intensive firms are judged heavily on resource reserves and asset quality.
		Ritonga et al. (2021)	Capital Structure / Consumer Goods BEI	Insignificant Effect: Changes in the composition of debt and equity do not generate any meaningful shifts in the firm's immediate financial performance.

2.8 Financial Performance

Financial performance reflects the outcomes of management strategies in leveraging the company's resources to achieve economic objectives optimally. Financial performance is generally measured through profitability levels, which reflect the company's success in utilizing resources and ensuring funds are allocated efficiently [46] . Financial statements are then used to evaluate past conditions while projecting future performance. In addition to serving as an indicator of financial stability and management effectiveness, financial performance also contributes to organizational motivation. Consequently, positive environmental performance has been demonstated to strengthen financial results through enhanced reputation, customer loyalty, efficiency, and reduced risk. Research indicates that business entities capable of demonstrating superior environmental performance tend to achieve a higher level of public legitimacy as recognition of their commitment and responsibility toward environmental sustainability, which ultimately contributes to more optimal financial performance [47] .

From a broader perspective, financial performance measures a company's capacity to achive optimal economic outcomes, maintain efficiency, and ensure long-term stability. This relates to how a company manages its internal resources and formulates strategic decisions that support financial sustainability. The implementation of Environmental, Social, and Governance

(ESG) practices constitutes one of the key determinants capable of driving improvements in financial performance, which have been proven to increase transparency, improve relationships with stakeholders, reduce risk, and drive operational efficiency [48] . Additionally, the level of transparency in sustainability reporting also has a significant impact. Regulations such as the Corporate Sustainability Reporting Directive (CSRD) drive improvements in reporting quality, which in turn enhances reputation, boosts investor confidence, and has positive implications for financial outcomes [49] . In the energy sector, this relationship is particularly evident, where companies that implement sustainability principles and maintain environmental accountability demonstrate stable profitability with minimal operational risk. Thus, financial performance can be understood as the outcome of a company's response to sustainability demands. In this research, Return on Assets (ROA) is utilized as a measure of financial performance [50] , with the following formula:

$$\textbf{ROA} = \frac{\textit{Net income}}{\textit{Total asset}}$$

The ROA was calculated using data from the Indonesia Stock Exchange's (IDX) statistical reports. This data encompasses information pertaining to a company's net income and total assets used to calculate the ratio.

2.9 Conceptual Framework

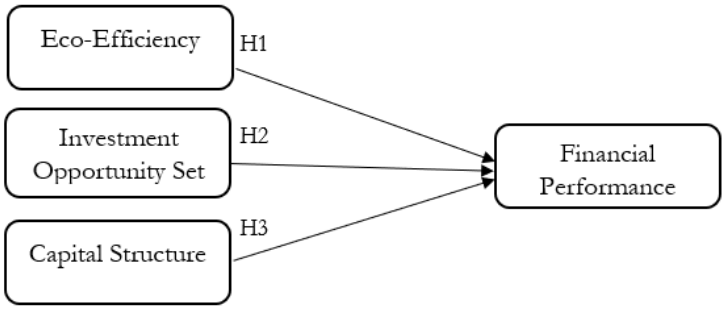

Figure 2. Conceptual Framework

2.10 Hypotheses

2.10.1 The Effect of Ecological Efficiency on Financial Performance

Ecological efficiency is viewed as a critical indicator in evaluating a company's ability to create economic value optimally while minimizing environmental impacts through efficient resource utilization and emission reduction [36], [37] . A high level of ecological efficiency reflects better operational efficiency and the potential for reduced production costs, which ultimately has the potential to enhance the company's profitability. Most companies report that ecological efficiency improves financial performance [11] . However, other studies have found that ecological efficiency does not always have a positive impact on financial performance [20], [21] . Given these differing findings, the formulated hypothesis is:

H^1 : Ecological efficiency has a positive and significant effect on financial performance

2.10.2 The Effect of the Investment Opportunity Set (IOS) on Financial Performance

The Investment Opportunity Set (IOS) reflects a company's growth opportunities stemming from its ability to manage and utilize value-added investments [13], [40], [41] . A high IOS indicates strong expansion prospects as well as the company's ability to improve asset utilization efficiency and profitability. The majority of studies have found that the IOS improves

financial performance [13], [14], [23], [24] . Based on these findings, the following hypotheses are formulated:

H^2 : The investment opportunity set has a positive and significant effect on financial

2.10.3 The Effect of Capital Structure on Financial Performance

Capital structure reflects the composition of debt utilization as a source of funding for the company's assets. Efficient management of capital structure can optimize funding efficiency and support the company's operational and investment activities [45] . However, excessive reliance on debt financing has the potential to increase interest expenses and financial risk, which ultimately suppresses profitability. The majority of prior studies indicate that capital structure exert negative impact on financial performance [29], [30], [31] . Based on these differing results, the following hypotheses are formulated:

H^3 : Capital structure has a negative and significant affects on financial performance

3. Proposed Method

This study employs a quantitative approach using an explanatory research design to investigate the impact of Ecological Efficiency, Investment Opportunity Set (IOS), and Capital Structure on Financial Performance among energy sector companies listed on the Indonesia Stock Exchange (IDX) over the 2022–2024 period. The analysis is based on secondary data sourced from corporate sustainability reports and annual reports available on the respective companie's official websites, complemented by statistical data obtained from the official IDX's platform (idx.co.id).

The scope of this research encompasses all energy sector firms listed on the IDX according to the IDX-IC (Indonesia Stock Exchange Industrial Classification) during the observation period. To obtain a representative sample, a purposive sampling method was employed, whereby firm were selected based on predefined criteria aligned with the objectives of the study. The selection criteria are follows:

a) Energy sector companies listed consecutively during the 2022–2024 period;
b) Companies that consistently publish sustainability reports containing information related to carbon emissions;
c) Firms that provide complete audited financial statements throughout the observation period;
d) Firms with complete data covering all research variables, including stock price data

Table 2. Sample Selection Criteria

No	Sample Selection Criteria	Number of Companies	Total Companies
1.	Firms operating with the energy sector and listed on the Indonesia Stock Exchange (IDX);	87	87
2.	Not listed consecutively during the 2022–2024 period;	(7)	80
3.	Energy firms that do not publicly disclose sustainability reports or carbon emissions data;	(22)	58
4.	Companies that do not have complete reports on stock information.	(15)	43
	Total Companies		43

Source: Processed data, 2025

Based on these criteria, a total of 43 companies met the requirements. To ensure the representativeness of the sample across the entire industry, Table 3 provides a detailed breakdown of the final sample composition across various energy sub-sector as defined by the IDX-IC.

Table 3. Sample Composition by Energy Sub-Sector

No	IDX-IC Sub Sector	Industry Description	Number of Companies	Total Companies
1.	Coal production (oil, gas, and coal)	Coal producion and mining	17	17
		Oil & gas production & distribution	6	23
		Oil, gas & coal support services	18	41
2.	Alternative/renewable energy		2	43
	Total Companies			43

Source: Processed data, 2025

These criteria ensure that the sample contains relevant data and can be analyzed using panel analysis with Eviews software. Based on this screening process, a total of 43 firms were identified, resulting 129 firm-year observations over the study period. In terms of variable specification financial performance, proxied by Return on Asset (ROA), serves as the dependent variable. ROA was selected over alternative measures such as ROE or ROS because, given the capital-intensive nature of the energy sector, it more accurately reflects management's efficiency in generating profit from total assets. Moreover, since capital structure is an independent variable, using ROE risks endogeneity bias, as ROE is sensitive to leverage and can be artificially inflated through debt rather than genuine operational efficiency. The independent variables consist of Ecological Efficiency, proxied by Emission Intensity (EI), Investment Opportunity Set, proxied by the Market-to-Book Value of Asset (MBVA), and Capital Structure, proxied by the Debt-to-Equity Ratio (DER). To analyze the relationships between variables, this study employs panel data regression analysis utilizing Eviews software. The regression model applied in this study is formulated as follows:

$$ROA_{it} = \beta_0 + \beta_1 EI_{it} + \beta_2 MBVA_{it} + \beta_3 DER_{it} + \varepsilon_{it}$$

Notes:

ROA_{it} : Financial performance of firm i in year t
EI_{it} : Ecological efficiency of company i in year t
$MBVA_{it}$: Investment opportunity set for firm i in year t
DER_{it} : Firm i's capital structure in year t
β_0 : Constant
β_1–β_3 : Regression coefficients
ε_{it} : Error term

To evaluate how accurately the regression model predicts real values, this research employs the F-test, T-test, and the coefficient of determination (R^2) as the key metrics for judging the model's reliability and forecasting ability.

4. Results and Discussion

Based on the data selection process using purposive sampling, this study identified 43 companies in the energy sector as a sample with a total of 129 observations. A panel data regression model was used for the analysis. The data processing began with calculating each variable according to the specified formulas, then compiling the results using Microsoft Excel. Subsequently, the analysis was conducted using EViews software through the stages of Descriptive Statistics, Normality Test, model selection tests (Chow, Hausman, and Lagrange Multiplier), and regression testing to produce outputs consistent with the research design.

4.1. Results

4.1.1 Descriptive Statistical Analysis

Descriptive statistics were used to present a comprehensive overview of the research data characteristics, including Return on Asset (ROA), Emission Intensity (EI), Market-to-Book Value of Assets (MBVA), and Debt-to-Equity Ratio (DER) for firms in the energy sector during the 2022 to 2024 period. The results of the observations in this study consist of 129 firm-year observations from 43 companies.

Table 4. Descriptive Statistics

	ROA	EI	MBVA	DER
Mean	0.049070	6.233084	1.449533	0.940195
Median	0.027800	2.420100	0.979300	0.700000
Maximum	0.530000	99.87860	13.06500	5.860000
Minimum	-1.530000	0.000000	0.153900	-0.400000
Std. Dev.	0.174214	11.70281	1.835282	1.054241

Source: Eviews 9, 2026

As presented in Table 4 of the descriptive statistics, the ROA metric has an average value of 0. 049070, which implies that businesses manage to earn a profit amounting to 4. 9% of their total assets. The highest recorded value is 0. 530000, while the lowest is -1. 530000, reflecting the existence of both highly successful companies and those facing financial losses. The EI variable shows an average of 6. 233084, with the highest value reaching 99. 87860 and the lowest at 0. 000000, indicating significant disparities in how companies implement ecological efficiency. In addition, the MBVA has a mean value of 1. 449533, with a peak of 13. 06500 and a bottom limit of 0. 153900, which highlights variations in investment prospects across different companies. On the other hand, the DER holds an average of 0. 940195, showing a maximum of 5. 860000 and a minimum of -0. 400000, suggesting that some firms engage in high levels of leverage, even to the point of negative equity. Additionally, all variables display standard deviations that exceed their means, indicating that the data observed in this analysis shows considerable variability or diversity.

4.1.2 Classical Assumption Test

Table 5. Normality Test

	Value
Probability	0.000000

Source: Eviews 9, 2026

According to the findings from the classical assumption test presented in Table 5, a probability figure of 0.000000 was reached. This figure is less than the significance level (<0.05), so it can be concluded that the data are not normally distributed. However, in panel data regression analysis, the normality assumption is not a primary requirement because panel estimates are consistent with a sufficient number of observations, so the analysis can proceed to the next stage [51].

4.1.3 Regression Analysis

Panel data regression analysis was performed to explore the connections between Ecological Efficiency, Investment Opportunity Set (IOS), and Capital Structure in terms of financial performance. There are three primary methods to assess panel data regression: the Common Effects Model (CEM), the Fixed Effects Model (FEM), and the Random Effects Model

(REM). To determine the most appropriate estimation model among these alternatives for this empirical study, a rigorous model selection process was executed, as detailed below.

4.1.3.1 Panel Data Estimation Model Selection

The process of choosing the best-suited model involves a sequence of statistical evaluations, specifically the Chow Test, the Hausman Test, and the Lagrange Multiplier (LM) Test, which are adapted to fit the specific nature of the data in question. According to [52], the optimal model selection is guided by formal decision rules using a significance level of **α = 5%** through a systematic elimination process.

a. Chow Test

The Chow test is employed to evaluatethe statistical preference between the CEM and FEM specifications. The decision rule dictates that if the probability value (p-value) of the Cross-section Chi-square is less than 0.05, the FEM is preferred; conversely, if the p-value exceeds 0.05. The CEM is selected [52]. The estimation results of the Chow test are presented in Table 6 below:

Table 6. Chow Test

	Prob.
Cross-section F	0.2315
Cross-section Chi-square	0.0265

Source: Eviews 9, 2026

As shown in Table 6, the test yields a Cross-section Chi-square probability value of 0.0265. Since this p-value is lower than the standard significance threshold (0.0265 < 0.05), the null hypothesis is rejected. Consequently, the Fixed Effect Model (FEM) is statistically more appropriate for this study than the Common Effect Model (CEM).

b. Hausman Test

Given that the Chow test favors the FEM specification, the selection process proceeds to the Hausman test to distinguish between the FEM and REM. This test operates under the criterion that a p-value below 0.05 indicates the preference for the FEM, whereas a p-value above 0.05 suggest that the REM is the more efficient and appropriate model [52]. The results of the Hausman test are displayed in Table 7 below:

Table 7. Hausman Test

	Prob.
Chi-Sq. Sta-tistic	2.100906
Prob. (p-value)	0.5517
Chi-Sq. d.f.	3

Source: Eviews 9, 2026

According to Table 7, the resulting p-value is 0.5517. Because this probability value is substantially greater than the significance level (0.5517 > 0.05), the null hypothesis cannot be rejected. This indicates that the Random Effect Model (REM) is more appropriate than the FEM, thereby officially eliminating the FEM specification from further consideration.

c. Lagrange Multiplier (LM) Test

The final stage of the sequential testing procedure involves conducting the Lagrange Multiplier (LM) test to verify whether the REM significantly outperforms the baseline Common Effect Model (CEM). The decision framework establishes that a Cross-section probability value below 0.05 selects the REM, while a value exceeding 0.05 confirms the suitability of the CEM [52]. The LM test estimation results are reported in Table 8 below:

Table 8. Lagrange Multiplier Test

	Prob.
Cross-section none	0.5831

Source: Eviews 9, 2026

According to Table 8, the Cross-section none probability value is 0.5831. Given that this p-value is greater than the critical threshold (0.5831 > 0.05), the null hypothesis is retained. Therefore, the Common Effect Model (CEM) is definitively selected as the most optimal estimation model for this empirical study.

In summary, this sequence of the statistical tests does not produce randomly conflicting outcome; rather it, constitutes a logical and robust process of elimination. The Hausman test successfully ruled out the FEM due to the absence of correlation between the individual specific effects and the explanatory variables, leaving the choice between the REM and CEM. Subsequently, the LM test conclusively rejected the REM, demonstrating that the variance of the individual specific effects is statistically equal to zero. Accordingly, the final selection of the Common Effect Model (CEM) in this study rests upon a rigid, methodologically sound, and statistically valid elimination framework.

Table 9. Panel Data Regression Test

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.051340	0.024622	2.085134	0.0391**
EI	-0.000448	0.001268	-0.353087	0.7246
MBVA	0.022726	0.008064	2.818336	0.0056***
DER	-0.034485	0.014036	-2.456960	0.0154**
R-squared	0.112600	Mean dependent var		0.049070
Adjusted R-squared	0.091302	S.D. dependent var		0.174214
S.E. of regression	0.166071	Akaike info criterion		-0.722291
Sum squared resid	3.447429	Schwarz criterion		-0.633615
Log likelihood	50.58778	Hannan-Quinn criter.		-0.686260
F-statistic	5.286979	Durbin-Watson stat		1.659028
Prob(F-statistic)	0.001824			

Source: Eviews 9, 2026

The results of the Common Effect Model regression estimation shown in Table 9 yield the following panel regression equation:

$$\mathbf{Y = 0.05140 - 0.000448X1 + 0.022726X2 – 0.0394485X3 + \varepsilon}$$

The panel data regression equation is interpreted as follows:

The ecological efficiency coefficient of -0. 000448 reveals an insignificant negative correlation between ecological efficiency and financial performance. This implies that improvements in ecological efficiency have not yet produced a measurable effect on the firm's financial results in the short-term. The IOS coefficient of 0. 022726 shows a positive and meaningful connec-

tion to financial performance, indicating that greater investment opportunities for the company reliably lead to an increase in ROA. On the other hand, the capital structure coefficient of -0. 0394485 demonstrates a significant negative link between leverage and financial performance. This suggests that increases in debt usage detrimentally affect financial performance due to growing interest costs and financial risk.

4.1.4 Hypothesis Testing

Table 10. Hypothesis Test Results

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.051340	0.024622	2.085134	0.0391
X1 (EE)	-0.000448	0.001268	-0.353087	0.7246
X2 (IOS)	0.022726	0.008064	2.818336	0.0056
X3 (DER)	-0.034485	0.014036	-2.456960	0.0154

Source: Eviews 9, 2026

Based on the test results shown in Table 10, the effect of each independent variable on financial performance (ROA) can be described in the following way:

The variable of Ecological Efficiency (X1) does not significantly influence financial performance, as indicated by a t-value of -0.353087 < the critical t-value (2.0195) and a significance level of 0.7246 (>0.05). Thus, H1 is rejected. The variable representing the Investment Opportunity Set (X2) positively influences financial performance, showing a computed t-value of 2.818336 > the critical t-value (2.0195) and a significance level of 0.0056 (<0.05). Thus, H2 is accepted. The variable representing Capital Structure (X3) adversely impact financial performance in a notable way. With a calculated t-value of -2.456960 < the critical t-value (2.0195) and significance value of 0.0154 (<0.05). Thus, H3 is accepted.

Table 11. F-Test

R-squared	0.112600
Adjusted R-squared	0.091302
S.E. of regression	0.166071
Sum squared resid	3.447429
Log likelihood	50.58778
F-statistic	5.286979
Prob(F-statistic)	0.001824

Source: Eviews 9, 2026

According to Table 11, the three independent variables collectively have a notable impact on ROA, demonstrated by an F-statistic value of 5.286979, which is surpasses the computed F value of (2.8451), alongside a Prob (F-Statistic) value of 0.001824 that exceeds the 5% significance threshold of (0.05). Furthermore, the (R^2) value of 0.112600 and the adjusted R-squared value 0.091302 suggest that these three independent variables explain 9.1% of the variation in financial performance, with the remaining 90.9% attributed to other factors outside the model. This relatively low explanatory power is common in panel data studies involving heterogeneous firms within a single industry, where financial performance is also shaped by factors nots captured in this model; such as firm size, corporate governance quality, liquidity, macroeconomis conditions (e.g., energy price volatility and exchange rate fluctuations), and firm specifics operational efficiency. Future research is therefore encouraged to incorporate these omitted variables, either as additional predictors or as moderating/control variables, to achieve a more comprehensive explanation of financial performance determinants in the energy sector.

4.2 Discussion

4.2.1 The Effect of Ecological Efficiency on Financial Performance in Energy Sector Companies

The test results show that ecological efficiency has a coefficient of -0.000448 with a p-value of 0.7246, which far exceeds the 5% significance level; therefore, H1 is rejected. Ecological efficiency does not significantly influence the financial outcomes of energy companies in Indonesia during 2022 – 2024, and its negative coefficient indicates that increased ecological efficiency tends not to be able to improve short-term profitability.

This finding is inconsistent with the Natural Resource-Based View (NRBV) introduced by Stuart L. Hart [10] , which posits that effective management of natural resources yields competitive advantages that improve financial performance through pollution prevention and product stewardship [53]. In the Indonesian energy sector during 2022-2024, however, most companies appear to still be in the pollution prevention phase of the NRBV continuum absorbing compliance costs rather than harvesting efficiency gains, which explains why the theory's predicted profitability premium has not yet materialized.

This outcome is attributable to the capital-intensive nature of the energy industry, where adoption of environmentally friendly technologies requires substantial upfront investment that suppresses near-term ROA [54]. Moreover, ecological efficiency in this sector is driven more by regulatory compliance than by value creation, and its benefits typically require a lengthy period to materialize beyond the scope of this three-year observation window [9], [11], [55], [56] .

This is evidenced within the sample data. PT Radiant Utama Interinsco Tbk (RUIS) recorded consistently low emission intensity (EI = 0.0325 in 2022, declining to 0.0003 by 2024) yet its ROA remained well below the sector mean throughout the period (ROA = 0.0002; 0.0091; 0.0100). Similarly, PT Rukun Raharja Tbk (RAJA) maintained an average EI of 0.017, well below the sector mean of 6.23, yet its average ROA of 0.046 still fell short of the sector mean of 0.049. Conversely, PT Medco Energi Internasional Tbk (MEDC) recorded the highest average emission intensity in the sample (average EI = 41.67 over 2022–2024) yet reported a ROA of 0.046 in 2024, virtually identical to RAJA's. The absence of any consistent pattern between EI and ROA across these firms directly supports the insignificant finding of this study.

These results align with the findings of Czerny & Letmath [20] and Puspita & Imronudin [22] , who assert that emission reduction strategies may enhance ecological performance without generating a direct effect on financial performance, as effective GHG mitigation strategies generally require a long timeframe and substantial capital investment commitments. This pattern is also evident beyond Indonesia, as similar insignificant relationships have been reported among Nigerian banks [57] and across emerging-market corporations more broadly [58]. These findings different from Daud [11] , showed that ecological efficiency positively and significantly influences financial performance among Indonesia Stock Exchange (IDX) listed companies during 2019 through 2021. The discrepancy is attributable to differences in sample scope and period, this study focuses exclusively on energy sector companies from 2022 to 2024, a period characterized by heightened energy transition pressure and commodity price volatility. Thus, ecological efficiency is expected to have a delayed impact on financial performance in Indonesia and other developing economies.

4.2.2 The Effect of the Investment Opportunity Set (IOS) on Financial Performance in Energy Sector Companies

The findings indicates that the Investment Opportunity Set (IOS) carries coefficient of 0.022726 and a probability value of 0.0056, which is less than 5% significance threshold; thus, H2 is accepted. This indicates that the IOS positively and significantly influences the financial performance of companies in the energy sector in Indonesia. In the other words, an increase

in the investment opportunities available to a company enchaces its potential for boosting profitability.

This findings are consistent with Signaling Theory [12] , which posits that firms with high growth potential credibly signal future cash flow and profit generation to investors, thereby boosting market confidence and financial performance [24]. A high MBVA ratio signals to the market that a firm possesses credible growth trajectories through resource expansion, energy transition investment, or technological upgrading reducing information asymmetry and lowering the cost of capital, which is ultimately reflected in superior ROA. In the energy sector, investment opportunities in renewable infrastructure, resource exploration, and technological advancement are critical drivers of improved financial performance, enabling firms to gain competitive advantage and enhance operational efficiency [13], [28], [29] .

This is exemplified by PT Bayan Resources Tbk (BYAN), which held the highest average MBVA in the sample (12.02 in 2022; 13.07 in 2023; 12.23 in 2024) and recorded among the highest ROA in the sector (0.530 in 2023; 0.268 in 2024). PT Golden Energy Mines Tbk (GEMS) presents a consistent pattern, with an average MBVA of 2.86 and average ROA of 0.308, both well above the sector mean. These cases corroborate the significant positive relationship identified in this study.

These findings are consistent with [13], [24], which confirm that IOS positively and significantly influences financial performance, and with [23], where capital expenditure proxied by CAPXlag directly improves ROA. In an energy sector undergoing structural transformation, companies that effectively capitalize on investment opportunities will achieve superior financial performance, affirming IOS as a key indicator of growth potential and economic value creation.

4.2.3 The Effect of Capital Structure on Financial Performance in Energy Sector Companies

The findings indicate that capital structure exhibits a coefficient of -0.034485 with a probability value of 0.00154, which is under the 5% significance level, leading to the acceptance of H3. This indicates a significant aand negative effect of capital structure on the financial performance in Indonesia's energy sector, suggesting that increased debt usage may weaken profitability.

These results are consistent with the Pecking Order Theory [35] , which posits that firms prioritize internal financing over external debt. As internal funds are depleted a common occurrence in the capital-intensive energy sector companies resort to debt, generating fixed interest obligations that erode net income and reduce ROA [25], [45], [59]. This mechanism is particularly acute in the Indonesian energy sector, where massive infrastructure and energy transition funding needs make debt dependence structurally unavoidable, while energy price volatility and regulatory uncertainty further amplify the profitability pressure of high leverage.

This burden is evidenced within the sample. PT Buma Internasional Grup Tbk (DOID) carried the highest average DER (5.28 in 2022; 4.98 in 2023; 5.86 in 2024), and its ROA was near zero or negative throughout the period (0.0002; 0.019; -0.042). PT Apexindo Pratama Duta Tbk (APEX) similarly maintained an average DER of 2.85 while recording negative ROA across all three years (-0.002; -0.007; 0.002). PT Mitra Energi Persada Tbk (KOPI) further illustrates the dynamic relationship: as its DER escalated from 0.96 (2022) to 3.06 (2024), its ROA deteriorated to -0.105 by 2024. These cases consistently reflect the negative impact of excessive leverage on profitability.

This finding is consistent with Anozie and Omokore' [18], [26] , who found that high leverage negatively impacts profitability through increased interest expenses and financial risk, and with Muhammed [25], who demonstrated that capital structure imbalances disrupt long-term financial stability. Thus, optimal capital structure management is a critical determinant of profitability in capital-intensive, high-risk industries such as the energy sector.

Overall, the results indicate that the financial performance of energy sector firms is more immediately influenced by investment opportunities and financing decisions than by ecological efficiency. The economic benefits of environmental sustainability practices require a longer horizon to materialize, while IOS and

5. Conclusions

The findings of this study demonstrate that ecological efficiency does not significantly influence short-term financial performance. This outcome highlights the substantial financial strain imposed by front-loaded capital investments in green technologies, coupled with regulatory shifts and volatile energy commodity prices that drive companies toward basic compliance rather than short-term economic value creation. Conversely, the Investment Opportunity Set (IOS) emerged as the dominant positive driver of financial performance, confirming that a rich pipeline of productive growth options enhances profitability. Meanwhile, an aggressive capital structure heavily reliant on debt significantly suppresses returns due to heightened financial risks and rising interest costs. Together, these variables simultaneously dictate the financial trajectory of energy sector companies. Moving forward, energy sector companies must transform these insights into proactive operational strategies rather than viewing environmental initiatives as passive compliance burdens. Management should adopt a multi-phased transition framework where ecological efficiency projects are prioritized based on their operational cost-offset capabilities, thereby mitigating initial capital strain. To buffer against cash flow constraints, companies must strategically exploit high-yield investment opportunities in renewable infrastructure while actively restructuring their leverage. This can be operationalized by migrating from high-cost commercial debt to alternative sustainable financing mechanisms, such as green bonds and sustainability-linked loans, which offer favorable interest structures tied to environmental milestones. Furthermore, corporate leadership must integrate environmental, social, and governance (ESG) risk management directly into long-term capital budgeting processes to maintain stakeholder legitimacy and ensure resilience against future regulatory shocks. For future academic work, extending the research timeline and incorporating advanced proxies, such as standardized ESG composite scores, is recommended. Future studies should also introduce moderating variables, such as government subsidies, institutional ownership, or technological capability maturity, to gain a more granular understanding of the mechanisms that bridge ecological efficiency and long-term sustainable corporate performance.

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