

The Effect of Carbon Emission Disclosure, Environmental Performance, and Intellectual Capital on Firm Value

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Abstract

This study aims to examine the effect of the Carbon Disclosure Project (CDP), Environmental Performance, and Intellectual Capital (Value Added Intellectual Coefficient-VAIC) on firm value, measured by Tobin's Q, in energy sector companies listed on the Indonesia Stock Exchange (IDX) during 2022–2024. This study employs a quantitative approach using secondary data obtained from annual, sustainability, financial, and Program Penilaian Peringkat Kinerja Perusahaan dalam Pengelolaan Lingkungan Hidup (PROPER) reports. The sample was selected using purposive sampling, resulting in 59 companies with 121 observations each. Data were analyzed using panel data regression with EViews 14, and the Random Effects Model (REM) was selected based on the Chow, Hausman, and Lagrange Multiplier tests. The results show that CDP has no significant effect on firm value, while environmental performance has a negative and significant effect on firm value. intellectual capital (VAIC) has a positive and significant effect on firm value. These findings indicate that carbon emission disclosure has not yet become a primary consideration for investors in assessing firm value, while environmental compliance costs may be perceived as short-term operational burdens. Conversely, effective intellectual capital management strengthens investor confidence and enhances firm value. This study is limited to energy sector companies and the 2022–2024 period. This study contributes empirical evidence on sustainability factors and intellectual capital concerning firm value in Indonesia.

Keywords: Carbon Disclosure Project, Company Value, Environmental Performance, Intellectual Capital

1. INTRODUCTION

Amid globalization and the increasing complexity of the global economy, corporate success is no longer evaluated solely on the basis of financial performance. Companies are increasingly expected to respond to various external challenges, including rising social expectations, sustainability regulations, and growing global concerns regarding environmental issues ([Alfallah, Komalasari, & Alvia, 2026](#)). These developments require firms to implement integrated managerial strategies that not only strengthen their competitive advantage but also ensure long-term business sustainability ([Dewi, 2025](#)).

Firm value, which reflects investors' perceptions of a company's current performance and future prospects in the capital market, is one of the primary indicators of corporate success ([Yamasitha & Pondrinal, 2025](#)). A higher firm value indicates stronger investor confidence in the company's financial strength, growth opportunities and long-term profitability. Moreover, companies with higher firm values generally have greater access to external financing from both capital markets and financial institutions because they are considered financially sound and capable of generating favorable investment returns ([Sakina & Hendrani, 2022](#)). The issue of firm value has become particularly relevant in Indonesia's energy sector, which represents one of the strategic sectors listed on the Indonesia Stock Exchange (IDX). The development of firm value in this sector can be illustrated by changes in market capitalization over the 2021–2024 period, as presented in Figure 1.

The development of technology in recent years has further strengthened the relationship between corporate strategy, sustainability, and firm value. The adoption of digital transformation, Artificial Intelligence (AI), the Internet of Things (IoT), big data, and clean energy technologies has encouraged companies, particularly those in the energy sector, to improve operational efficiency while responding to increasingly complex environmental demands. These technologies enable firms to monitor emissions more accurately, optimize energy consumption, improve resource efficiency, and provide more transparent sustainability information to investors. At the same time, the ability to adopt and manage technological innovations increasingly depends on the quality of human resources, organizational knowledge, innovation capabilities, and internal systems, which constitute important

components of intellectual capital. Therefore, technological development is not only an instrument for improving operational performance but also an important factor that can shape investors' perceptions of a company's growth prospects and long-term sustainability, ultimately influencing firm value.

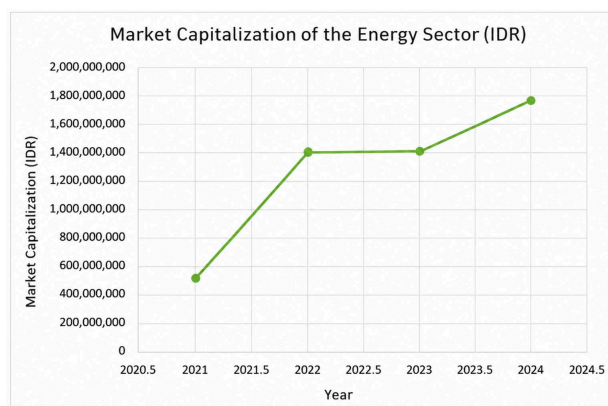


Figure 1. Market capitalization growth of the energy sector on the Indonesia Stock Exchange

Figure 1 shows the market capitalization of Indonesia's energy sector exhibited a consistent upward trend during the 2021–2024 period. Market capitalization increased from IDR 556.4 trillion in 2021 to IDR 1,424.0 trillion in 2022, followed by a slight increase to IDR 1,429.1 trillion in 2023 before reaching IDR 1,772.1 trillion in 2024. This upward trend indicates that the energy sector continues to attract substantial investor interest in the Indonesian capital market. However, a continuous increase in market capitalization does not necessarily imply that every company within the sector experiences a high firm value. According to [Ningrum \(2021\)](#), firm value is influenced by a combination of financial and nonfinancial factors. In recent years, investors have increasingly incorporated corporate sustainability aspects into their investment decisions, including carbon emissions disclosure, environmental performance, and intellectual capital management ([Ningrum, 2021](#)). These variables have been extensively examined in previous studies; however, the empirical findings remain inconclusive.

For example, [Kurnia and Putra \(2020\)](#) reported that carbon emission disclosure positively influences firm value, whereas [Anggita and Suhaidar \(2022\)](#) found no significant relationship between these variables. [Khanifah and Alfiana \(2020\)](#) concluded that environmental performance positively and significantly affects firm value, while [Alzura \(2025\)](#) found insignificant results. In addition, [Gaol and Irawati \(2021\)](#) found that intellectual capital positively affects firm value, whereas [Azhari and Hasibuan \(2023\)](#) reported no significant association between the two. These inconsistencies indicate that the effects of carbon emission disclosure, environmental performance, and intellectual capital on firm value are still theoretically and empirically unresolved, suggesting that additional contextual or methodological factors may moderate these relationships.

A closer examination of these prior studies reveals several limitations that this study seeks to address. First, most existing studies examine carbon emission disclosure, environmental performance, and intellectual capital separately rather than simultaneously, which limits the understanding of how financial, environmental, and intangible asset dimensions jointly shape investor valuation. Second, the majority of these studies are conducted on manufacturing or general industrial samples, while energy sector companies, which face distinct regulatory pressure, carbon exposure, and capital intensity, remain underexplored, despite the sector's strategic and environmentally sensitive nature within the Indonesian economy. Third, variations in measurement approaches, sample periods, and firm characteristics across studies further contribute to the inconsistency of the findings, indicating a need for updated empirical evidence within a more homogeneous and contextually relevant sample.

The inclusion of intellectual capital is based on the premise that intangible assets play a crucial role in generating sustainable competitive advantages and enhancing firm value. Intellectual capital enables companies to improve innovation, organizational efficiency, and knowledge-based

capabilities, all of which are increasingly recognized as essential determinants of long-term corporate success. Building on the identified gaps, the novelty of this study lies in its simultaneous examination of carbon emission disclosure, environmental performance, and intellectual capital as determinants of firm value within a single empirical model, specifically for energy sector companies listed on the Indonesia Stock Exchange. Unlike prior studies that generally isolate these variables or focus on non-energy industries, this study integrates environmental and intangible asset dimensions within a sector that is both highly capital-intensive and increasingly subject to sustainability scrutiny. This study aims to provide a more comprehensive and context-specific understanding of how sustainability-related and knowledge-based factors jointly influence firm value, thereby offering theoretical contributions to the firm value literature and practical insights for investors and policymakers in the energy sector.

2. LITERATURE REVIEW

2.1 Legitimacy Theory

Legitimacy theory was first introduced by [Dowling and Pfeffer \(1975\)](#), who argued that establishing and maintaining a harmonious relationship between an organization and society is essential for its long-term survival. This theory explains that companies voluntarily disclose environmental information in response to social expectations and public pressure. By obtaining public legitimacy through such disclosures, organizations can maintain social acceptance and ensure the sustainability of their business operations. In the context of this study, carbon emissions disclosure and environmental performance represent corporate accountability for environmental issues. These practices demonstrate compliance with the prevailing social norms and environmental regulations. Transparent disclosure through sustainability reports, annual reports, and the government's PROPER environmental rating is expected to strengthen corporate reputation, enhance public trust, and ultimately increase firm value ([Ritongah Kastilon & Reflis., 2024](#)).

Beyond environmental responsibility, intellectual capital plays an important role in gaining organizational legitimacy. Effective management of human resources, organizational systems, knowledge, and innovation reflects a firm's capability to create sustainable value. The disclosure of intellectual capital provides positive signals regarding a company's future competitiveness and growth potential, thereby strengthening investors' confidence and enhancing firm value ([Yahya Salin & Alias, 2022](#)). Taken together, these arguments suggest that legitimacy theory offers a unifying theoretical lens for this study: carbon emission disclosure, environmental performance, and intellectual capital disclosure can all be understood as legitimacy-seeking mechanisms through which firms signal responsible resource management to stakeholders. However, the extent to which such legitimacy-seeking behavior translates into higher firm value remains empirically contested, as reflected in the inconsistent findings of prior studies discussed below this section. This suggests that the strength of the legitimacy–firm value relationship may be contingent on industry characteristics, disclosure quality, and measurement approach, an issue this study addresses by focusing specifically on the energy sector, where environmental and reputational pressures are particularly salient.

2.2 Firm Value

Firm value reflects stakeholders' confidence in a company's ability to manage its resources efficiently while conducting business activities responsibly. It is formed through investors' assessments of management performance in meeting both economic and social expectations ([Indrarini, 2019](#)). The firm value can be measured using the Tobin Q ratio. Within the framework of legitimacy theory, Tobin's Q is a particularly appropriate proxy for firm value in this study, as it captures market-based investor perceptions rather than purely accounting-based performance, making it sensitive to how legitimacy-enhancing disclosures (environmental and intellectual capital-related) are priced by the market.

2.3 Carbon Emission Disclosure

Carbon emissions refer to the release of carbon-based compounds into the Earth's atmosphere as a consequence of various human and industrial activities ([Setiani, 2020](#)). Carbon emission disclosure is defined as a company's effort to identify, measure, and report the amount of carbon emissions generated through its operational activities, while communicating its commitment to emission

reduction initiatives. This disclosure reflects corporate environmental responsibility and is generally voluntary. It also provides valuable information for investors to evaluate a company's environmental commitment and long-term sustainability before making investment decisions. According to [Mondal, Akter, Moni, and Polas \(2023\)](#), companies that voluntarily disclose carbon emission information tend to receive more favorable responses from investors because they are perceived to have stronger managerial capabilities and greater environmental awareness. Consequently, such disclosures may positively contribute to firm value. Carbon emission disclosure in this study was measured using content analysis of annual and sustainability reports based on the Carbon Disclosure Project (CDP) framework. The disclosure index consists of five dimensions, such as climate change: risks and opportunities, greenhouse gas emissions, energy consumption, greenhouse gas reduction and associated costs, and carbon emission accountability.

From a legitimacy theory perspective, carbon emission disclosure functions as a symbolic and substantive legitimization strategy, particularly for energy sector firms that face direct public scrutiny over emissions. This theoretical prediction is consistent with the positive relationship reported by [Kurnia and Putra \(2020\)](#), yet contradicts the findings of [Anggita and Suhaidar \(2022\)](#), who found no significant effect. This inconsistency indicates that the legitimizing effect of carbon disclosure on firm value may not be automatic, but instead depends on factors such as disclosure credibility, sector-specific carbon exposure, and investor sophistication, which are particularly pronounced in the energy sector examined in this study.

2.4 Environmental Performance

Environmental performance refers to a company's systematic efforts to manage and control the environmental impact arising from its operational activities ([Sapulette & Limba, 2021](#)). According to [Mardiana and Wuryani \(2019\)](#), companies that demonstrate stronger environmental management are more likely to build a favorable corporate image among shareholders. Such positive perceptions may increase firm value by enhancing investor confidence. Consequently, superior environmental performance enables companies to gain public trust, particularly from investors, which ultimately enhances firm value ([Paramitha & Sudana, 2021](#)). In this study, environmental performance was measured using the Program for Pollution Control, Evaluation, and Rating (PROPER) issued by the Indonesian Ministry of Environment and Forestry.

Unlike carbon emission disclosure, which is self-reported and voluntary, PROPER ratings are independently assessed by a government authority, making environmental performance a more objective and verifiable signal of legitimacy. This distinction may explain why empirical evidence on this variable is similarly mixed. [Khanifah and Alfiana \(2020\)](#) found a significant positive effect, whereas [Alzura \(2025\)](#) reported insignificant results. Such divergence suggests that the legitimacy value of environmental performance ratings may depend on the extent to which investors actively monitor and interpret PROPER scores when making investment decisions, an assumption that has rarely been tested specifically within Indonesia's energy sector.

2.5 Intellectual Capital

Intellectual capital represents a company's intangible assets, including knowledge, information, organizational capabilities, and employees' expertise, which collectively create competitive advantages ([Sari & Putri, 2021](#)). Information on intellectual capital is increasingly important to stakeholders because it reflects a company's future growth potential ([Siregar & Safitri, 2019](#)). Companies with higher levels of intellectual capital generally exhibit superior financial performance, as they can generate greater value through innovation, operational efficiency, and continuous improvement. Moreover, intellectual capital serves as a sustainable source of competitive advantage because organizational knowledge and innovation are difficult to imitate ([Agustina, 2021](#)).

Theoretically, intellectual capital differs from the two environmental variables above in that its legitimacy value stems primarily from signaling future competitiveness rather than compliance with social or environmental norms. This distinction may account for the conflicting findings between [Firmansyah and Irawati \(2021\)](#), who found a significant positive effect, and [Azhari and](#)

[Hasibuan \(2023\)](#), who found no significant relationship between the two. Such inconsistency implies that the market's ability to price intellectual capital into firm value may vary by industry, particularly in sectors like energy, where value creation has traditionally been viewed as driven by physical and financial capital rather than intangible assets

Overall, legitimacy theory provides a coherent theoretical basis for expecting that carbon emissions disclosure, environmental performance, and intellectual capital positively influence firm value, as each reflects a distinct pathway through which firms seek social and market acceptance. However, the mixed empirical evidence reviewed above indicates that these legitimacy-seeking mechanisms do not uniformly translate into higher firm value across contexts. This gap between theoretical prediction and empirical inconsistency underscores the need to examine these three variables simultaneously within a single, sector-specific model, as their combined effect and the extent to which they reinforce or substitute one another in shaping investor perceptions have not been adequately tested in Indonesia's energy sector. This theoretical and empirical justification forms the basis for the hypotheses and conceptual framework developed in the following section.

2.6 Carbon Emission Disclosure and Firm Value

Increasing public awareness of climate change has intensified the pressure on companies to disclose environmental information related to their operational activities ([Gazani & Aryani, 2021](#)). Carbon emission disclosure demonstrates corporate responsibility toward environmental sustainability and serves as a mechanism for reducing information asymmetry while enhancing organizational legitimacy ([Gazani & Aryani, 2021](#)). The logic underlying this relationship can be traced to several interconnected mechanisms. First, carbon emission disclosure reduces information asymmetry between management and external stakeholders by providing verifiable data on a firm's environmental risk exposure, which is particularly material for energy sector companies, given their inherently carbon-intensive operations. Second, this reduction in information asymmetry lowers investors' perceived risk regarding potential future regulatory costs, such as carbon taxes or emission-related penalties, thereby making the firm's future cash flows more predictable. Third, from a signaling perspective, voluntary disclosure signals that management possesses superior internal environmental monitoring systems and is confident enough in its environmental performance to make it public, a costly signal that is difficult for poorly performing firms to imitate.

Companies that voluntarily disclose carbon emission information are generally perceived as environmentally responsible, thereby encouraging positive investor responses ([Anggita & Suhaidar, 2022](#)). Higher investor confidence may increase the demand for company shares, resulting in higher stock prices and improved firm value. This argument is consistent with Legitimacy Theory, which suggests that organizations seek to gain and maintain social legitimacy by aligning their activities with societal expectations. Carbon emissions disclosure enhances a company's public image as an environmentally responsible organization, thereby strengthening market confidence. Previous studies by [Pelawi and Inawati \(2024\)](#) and [Ramdani and Nugraha \(2024\)](#) also reported a positive relationship between carbon emission disclosure and firm value. Taken together, these arguments suggest that carbon emissions disclosure operates simultaneously as a risk-reduction mechanism and a legitimacy signaling mechanism, both of which are expected to be positively priced by the market in the form of higher firm value.

2.7 Environmental Performance and Firm Value

Environmental performance reflects a company's capability to manage its environmental responsibilities effectively ([Safitri & Sukarmanto, 2021](#)). Unlike carbon emission disclosure, which is self-reported, environmental performance, as measured through PROPER, is independently verified by a government authority, which arguably makes it a more credible signal to the market. The underlying logic is that a favorable PROPER rating certifies, through an external and objective party, that a firm's operational practices meet or exceed regulatory environmental standards. This third-party verification reduces the risk of investors being misled by self-serving disclosures, thereby lowering the perceived agency risk associated with a firm's environmental claims. In addition, strong

environmental performance may reduce firms' exposure to regulatory sanctions, environmental litigation, and reputational damage from environmental incidents, all of which represent potential future costs that would otherwise be discounted into the firm's valuation.

Companies that achieve superior environmental performance tend to develop a positive reputation among investors, which may increase stock prices and ultimately enhance firm value ([Kodriyah Kurnia et al., 2023](#)). According to Legitimacy Theory, firms that successfully obtain public legitimacy through responsible environmental practices are more likely to improve their market value. Previous studies by [Mardiana and Wuryani \(2019\)](#), [Sapulette and Limba \(2021\)](#), and [Budiharjo \(2019\)](#) consistently found that environmental performance positively influences firm value. Accordingly, superior environmental performance is expected to enhance firm value not only through reputational benefits but also through the reduction of anticipated regulatory and litigation-related costs.

H₂: Environmental Performance significantly affects Firm Value

2.8 Intellectual Capital and Firm Value

Intellectual capital is a strategic organizational resource that creates value and strengthens competitive advantage. The theoretical rationale connecting intellectual capital to firm value operates through resource-based logic: because intellectual capital comprising human, structural, and relational capital is intangible, firm-specific, and difficult for competitors to replicate, it constitutes a more sustainable source of competitive advantage than physical or financial capital alone. Efficient utilization of intellectual capital, as captured by the VAIC™ model, indicates that a firm can generate greater value added per unit of physical, financial, and human capital employed. Investors are expected to interpret higher VAIC™ scores as an indication of superior managerial quality and stronger future earning capacity, since firms that manage their intangible resources effectively are generally better positioned to sustain innovation and adapt to competitive and regulatory changes, an especially relevant capability in the energy sector, which is undergoing significant transformation toward more sustainable business models.

Effective management of intellectual capital enhances innovation capability, operational efficiency, and decision-making quality, thereby improving corporate performance. Strong intellectual capital also provides positive signals to investors regarding a company's ability to generate sustainable economic value. Consequently, firms with higher intellectual capital are expected to achieve higher market valuations, whereas inadequate management of intellectual assets may reduce firm value ([Budianto, 2018](#)). This proposition is supported by [Yeye and Egbunike \(2023\)](#), who demonstrated that intellectual capital has a positive and significant effect on firm value. Based on this reasoning, intellectual capital is expected to positively influence firm value by strengthening investors' expectations of the firm's future value-generating capacity relative to its resource base.

H₃: Intellectual Capital significantly affects Firm Value

3. RESEARCH METHODOLOGY

This study employed a quantitative research approach to examine the effects of carbon emissions disclosure, environmental performance, and intellectual capital on firm value. The population consisted of all energy sector companies listed on the Indonesia Stock Exchange (IDX) during the 2022–2024 period, totaling 91 companies. The research sample was selected using a purposive sampling technique based on predetermined selection criteria, resulting in 59 companies with 121 firm-year observations. Secondary data were collected from the annual, sustainability, and financial reports of the sampled companies. These documents were obtained from the official website of the Indonesia Stock Exchange and the respective corporate websites. Data analysis was performed using E-Views 14 software.

The analytical procedures included descriptive statistical analysis, classical assumption tests, panel data model selection, panel data regression analysis, and hypothesis testing. The panel data estimation model was determined through three sequential specification tests, such as Chow,

Hausman, and Lagrange Multiplier (LM) tests. These tests were conducted to identify the most appropriate panel regression model among the Common Effects Model (CEM), Fixed Effects Model (FEM), and Random Effects Model (REM). After selecting the optimal estimation model, a panel data regression analysis was employed to examine the effects of carbon emission disclosure, environmental performance, and intellectual capital on firm value. The proposed hypotheses were subsequently evaluated using the t-test to assess the partial effects of each independent variable, the F-test to examine the simultaneous effect of all independent variables, and the coefficient of determination (Adjusted R^2) to measure the explanatory power of the regression model.

3.1 Variable Measurement

3.1.1 Firm Value

Firm value in this study is measured using Tobin's Q, which reflects the market's valuation of a firm relative to the replacement cost of its assets. Tobin's Q is calculated as follows:

$$Tobin's Q = \frac{MVE + DEBT}{TA} \quad (1)$$

Formula 1 shows MVE is the market value of equity (closing stock price $\times$ number of shares outstanding), DEBT is the total book value of liabilities, and TA is the total book value of assets. A Tobin's Q value greater than one indicates that the market values the firm above the replacement cost of its assets, reflecting favorable growth prospects.

3.1.2 Carbon Emission Disclosure

Carbon emission disclosure was measured using a content analysis approach based on the carbon disclosure project framework. Each sampled company's annual and sustainability reports were manually reviewed and scored using a dichotomous scoring method, in which a disclosure item is scored 1 if disclosed and 0 if not disclosed. The disclosure index consists of five dimensions, such as climate change: risks and opportunities, greenhouse gas emissions, energy consumption, greenhouse gas reduction and associated costs, and carbon emission accountability, comprising a total of 18 disclosure items. The Carbon Emission Disclosure Index (CEDI) for each firm is calculated as follows:

$$\text{Carbon Emission Disclosure} = \frac{\text{Number of Items Reported}}{\text{Number of Items Required to be CDP}} \quad (2)$$

Formula 2 shows the resulting index ranges from 0 to 1, with a higher value indicating a greater extent of carbon emission disclosure. To ensure scoring consistency, content analysis was conducted independently and cross-checked against the disclosure checklist prior to data tabulation. This measurement approach enables a systematic and objective assessment of companies' transparency in reporting carbon-related information and supports comparability across firms within the research sample.

3.1.3 Environmental Performance

Environmental performance is measured using the Program for Pollution Control, Evaluation, and Rating (PROPER), issued annually by the Indonesian Ministry of Environment and Forestry. The PROPER classifies corporate environmental performance into five color-coded rating categories, which are converted into an ordinal scale for statistical analysis, as follows:

Table 1. PROPER rating classification and environmental performance score

Proper Rating	Description	Score
Gold	Exceptional environmental performance of the proposed model	5
Green	Environmental performance exceeding compliance requirements	4
Blue	Environmental performance that meets compliance requirements	3
Red	Environmental performance is below compliance requirements	2
Black	Non-compliance and causing environmental damage	1

Table 1 shows the PROPER rating is used to measure corporate environmental performance based on five categories. The gold rating (score 5) represents outstanding environmental performance that exceeds regulatory requirements through sustainable and innovative practices. The green rating (score 4) indicates environmental performance that goes beyond compliance standards. The blue rating (score 3) reflects companies that meet the required environmental compliance standards. The red rating (score 2) indicates that environmental performance remains below the established compliance requirements. Meanwhile, the black rating (score 1) represents the lowest level of performance, characterized by serious non-compliance and environmental damage. Higher PROPER scores indicate better environmental performance and stronger corporate commitment to environmental management.

3.1.4 Intellectual Capital

Intellectual capital is measured using the value-added intellectual coefficient (VAICTM) model, which aggregates three components, such as Value-Added Capital Employed (VACA), Value-Added Human Capital (VAHU), and Structural Capital Value-Added (STVA). Intellectual Capital (VAIC) is measured through several components that reflect the company's ability to create value from its resources. First, Value Added (VA) is calculated as the difference between output and input using the formula:

$$VA = OUT - IN \quad (3)$$

Formula 3 shows OUT represents total sales and other operating income, while IN represents all operating costs incurred in generating revenue, excluding employee costs because employee costs are considered investments in human capital rather than expenses. Second, Value Added Capital Employed (VACA) measures the value added generated by each unit of physical and financial capital, calculated as:

$$VACA = VA/CE \quad (4)$$

Formula 4 shows VA (Value Added) represents the value created by the company through its operational activities, and CE (Capital Employed) refers to the book value of the company's net assets or total equity. A higher VACA value indicates that the company is more efficient in utilizing its available capital resources to generate economic value. Third, Value Added Human Capital (VAHU) evaluates the contribution of human resources to value creation, calculated as:

$$VAHU = VA/HC \quad (5)$$

Formula 5 shows where VA (Value Added) represents the value generated from the company's operational activities, and HC (Human Capital) refers to total employee expenses, including salaries and benefits. A higher VAHU value indicates that the company is more effective in utilizing its human

resources to generate greater economic value. Finally, Structural Capital Value Added (STVA) measures the contribution of structural capital in generating value, calculated as:

$$STVA = SC/VA \quad (6)$$

Formula 6 shows where SC (Structural Capital) represents the organizational resources, systems, processes, and infrastructure that support business operations, calculated as the difference between value added and human capital ($SC = VA - HC$), while VA (Value Added) represents the total value created by the company. A higher STVA value indicates that the company has stronger structural capabilities to support employees and improve overall value creation efficiency. The overall intellectual capital performance is calculated by summing the three components:

$$VAIC^{TM} = VACA + VAHU + STVA \quad (7)$$

Formula 7 shows A higher $VAIC^{TM}$ score indicates more efficient utilization of a firm's intellectual and physical resources in creating value. This suggests that the company has a stronger capability to manage human capital, structural capital, and employed capital effectively in supporting operational performance and enhancing value creation. Therefore, $VAIC^{TM}$ serves as an indicator of the company's competitive advantage through effective resource management and knowledge-based value generation.

4. RESULTS AND DISCUSSION

4.1 Descriptive Statistics

Table 2. Descriptive statistics

	CDP_X1	PROPER_X2	VAIC_X3	TOBINQ_Y
Mean	0.619834	3.479339	11.26948	1.235719
Median	0.666667	3.000000	6.900135	0.972000
Maximum	1.000000	5.000000	124.2279	3.981000
Minimum	0.055556	3.000000	-31.88361	0.324000
Std. Dev.	0.260678	0.719944	17.26089	0.654873
Skewness	-0.338415	1.148841	3.505710	1.706845
Kurtosis	2.229613	2.866153	20.66920	6.309043
Jarque-Bera	5.301795	26.70703	1821.860	113.9570
Probability	0.070588	0.000002	0.000000	0.000000
Sum	74.99989	421.0000	1363.607	149.5220
Sum Sq. Dev.	8.154374	62.19835	35752.59	51.46303
Observations	121	121	121	121

Table 2 shows the characteristics of each research variable are summarized as follows. Firm value (Tobin's Q) shows a minimum value of 0.324000, a maximum value of 3.981000, a mean value of 1.235719, and a standard deviation of 0.654873, indicating variations in market valuation among the observed companies. Carbon Disclosure (CDP) has a minimum value of 0.055556, a maximum value of 1.000000, a mean value of 0.619834, and a standard deviation of 0.260670, reflecting differences in the extent of carbon emission disclosure practices across firms. Environmental Performance (PROPER) ranges from a minimum value of 3.000000 to a maximum value of 5.000000, with a mean value of 3.479339 and a standard deviation of 0.719944, indicating that most companies demonstrate compliance with environmental standards. Meanwhile, Intellectual Capital (VAIC) has a minimum value of 31.88361, a maximum value of 124.22790, a mean value of 11.26948, and a standard deviation of 17.26080, suggesting differences in the efficiency of intellectual capital

utilization among the sampled companies. Overall, the descriptive statistics indicate variations in firm characteristics and resource management capabilities within the energy sector companies listed on the Indonesia Stock Exchange.

4.2 Classical Assumption Test

4.2.1 Heteroscedasticity Test

Table 3. Heteroscedasticity test results

Heteroskedasticity Test: ARCH		
F-statistic	0.740188 Prob. F(1.118)	0.3913
R-squared	0.748041 Prob. Chi-Square(1)	0.3871

Table 3 shows the Autoregressive Conditional Heteroskedasticity (ARCH) test produced an Obs R-squared value of 0.7480 with a prob. Chi-Square value of 0.3871, which exceeds the significance level of 0.05. Therefore, the null hypothesis cannot be rejected, indicating that the regression residuals exhibit a constant variance. Accordingly, the estimated regression model was free from heteroscedasticity and was appropriate for further statistical analysis.

4.2.2 Multicollinearity Test

Table 4. Multicollinearity test results

Variance Inflation Factors			
Variables	Coefficient Variance	Uncentered VIF	Centered VIF
C	0.073368	25.19931	NA
CDP_X ₁	0.049753	7.716907	1.151618
PROPER_X ₂	0.006526	28.28605	1.152158
VAIC_X ₃	1.03E-05	1.494040	1.044915

Table 4 shows the multicollinearity test revealed that all independent variables had centered Variance Inflation Factor (VIF) values well below the threshold of 10. Therefore, no multicollinearity problem exists among the explanatory variables, indicating that each independent variable provides distinct explanatory information in the regression model. This result confirms that the regression model is statistically reliable and that the estimated coefficients can be interpreted without bias caused by excessive correlation among independent variables.

4.2.3 Autocorrelation Test

Table 5. Autocorrelation test results

R-squared	0.199069	Mean dependent var	1.235719
Adjusted R-squared	0.178532	S.D. dependent var	0.654873
S.E. of regression	0.593543	Akaike info criterion	1.827086
Sum squared resid	41.21836	Schwarz criterion	1.919509
Log likelihood	-106.5387	Hannan-Quinn criter.	1.864622
F-statistic	9.693304	Durbin-Watson stat	2.048854
Prob (F-statistic)	0.000009		

Table 5 shows the Durbin Watson statistic obtained from the regression model was 2.0489. Based on the Durbin–Watson decision criteria at the 5% significance level with 121 observations and three independent variables, this value falls within the acceptance region, indicating the absence of both positive and negative autocorrelations. Therefore, the regression model satisfies the autocorrelation assumption and is appropriate for subsequent estimations.

4.3 Panel Data Model Selection

4.3.1 Chow Test

Table 6. Chow test results

Redundant Fixed Effects Tests			
Equation: FIXEDMODEL Test cross-section fixed effects			
Effects Test	Statistic	d.f.	Prob.
Cross-section F	5.821459	(55.62)	0.0000
Cross-section Chi-square	220.069707	55	0.0000

Table 6 shows the Chow test produced probability values of 0.0000 for both the Cross-section F and Cross-section Chi-square statistics. Since these values are below the 5% significance level, the null hypothesis is rejected, indicating that the Fixed Effects Model (FEM) is preferred over the Common Effects Model (CEM). This result indicates that individual company characteristics significantly influence the dependent variable, making the fixed effects approach more appropriate for capturing unobserved heterogeneity across cross-sectional units.

4.3.2 Hausman Test

Table 7. Hausman test results

Equation: RANDOM Test cross-section random effects			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	2.084646	3	0.5550

Table 7 shows the Hausman test generated a probability value of 0.5550, which exceeded the 5% significance level. Consequently, the null hypothesis cannot be rejected, indicating that the Random Effects Model (REM) is more appropriate than the Fixed Effects Model (FEM). This finding suggests that the individual effects in the model are not significantly correlated with the explanatory variables, allowing the REM approach to provide more efficient and consistent parameter estimates.

4.3.3 Lagrange Multiplier Test

Table 8. Lagrange multiplier test result

	Cross-section	Test Hypothesis Time	Both
Breusch-Pagan	27.35344	1.381945	28.73539
	(0.0000)	(0.2398)	(0.0000)

Table 8 shows the Breusch–Pagan Lagrange Multiplier test yielded a cross-section probability value of 0.0000, which is below the significance threshold of 0.05. Accordingly, the null hypothesis is rejected, indicating that the Random Effects Model (REM) is superior to the Common Effects Model (CEM). Based on the results of the Chow, Hausman, and Lagrange Multiplier tests, the Random Effects Model (REM) was selected as the most appropriate estimation model for this study.

4.3.4 Panel Data Regression Analysis

Table 9. Random effects regression results

Variables	Coefficient	Std. Error	t-Statistic	Prob.
C	1.612183	0.302653	5.326829	0.0000
CDP_X ₁	0.222811	0.200656	1.110410	0.2691
PROPER_X ₂	-0.185487	0.088672	-2.091840	0.0386
VAIC_X ₃	0.013745	0.002961	4.642679	0.0000
Effects Specification				
			S.D.	Rho
Cross-section random			0.505651	0.7033
Idiosyncratic random			0.328438	0.2967

Variables	Coefficient	Std. Error	t-Statistic	Prob.
Weighted Statistics				
R-squared		0.183362	Mean dependent var	0.497224
Adjusted R-squared		0.162422	S.D. dependent var	0.379984
S.E. of regression		0.331705	Sum squared resid	12.87328
F-statistic		8.756771	Durbin-Watson stat	2.112082
Prob(F-statistic)		0.000028		
Unweighted Statistics				
R-squared		0.189927	Mean dependent var	1.235727
Sum squared resid		41.69506	Durbin-Watson stat	0.652101

Table 9 shows the regression model has an Adjusted R-squared value of 0.162422, indicating that Carbon Emission Disclosure (CDP), Environmental Performance (PROPER), and Intellectual Capital (VAIC) explain 16.24% of the variation in firm value. The F-test results show that the model is statistically significant (Prob. F-statistic=0.000028), confirming that the independent variables simultaneously affect firm value. Partially, CDP has a positive but insignificant effect, PROPER has a negative and significant effect, while VAIC has a positive and significant effect on firm value. The estimated panel regression equation is as follows:

$$TOBINQ = 1,612183 + 0,222811CDP - 0,185487PROPER + 0,013745VAIC + \varepsilon \quad (8)$$

Formula 8 shows the estimated coefficients can be interpreted as follows. The constant coefficient of 1.612183 indicates that when all independent variables are assumed to be constant, the expected value of firm value is 1.612183. The coefficient of Carbon Emission Disclosure (CDP) is 0.222811, indicating that a one-unit increase in carbon emission disclosure is associated with an increase of 0.222811 in firm value, assuming all other variables remain unchanged. Meanwhile, the coefficient of Environmental Performance (PROPER) is 0.185487, suggesting that a one-unit improvement in environmental performance is associated with a decrease of 0.185487 in firm value, ceteris paribus. Finally, the coefficient of Intellectual Capital (VAIC) is 0.013745, indicating that a one-unit increase in intellectual capital efficiency contributes to an increase of 0.013745 in firm value, while controlling for other variables in the model. Overall, the coefficients describe the direction and magnitude of the relationship between each independent variable and firm value within the regression model.

4.4 Model Evaluation

4.4.1 Partial Hypothesis Testing (t-test)

Table 10. Partial hypothesis testing results

Variables	Coefficient	Std. Error	t-Statistic	Prob.
C	1.612183	0.302653	5.326829	0.0000
CDP X_1	0.222811	0.200656	1.110410	0.2691
PROPER X_2	-0.185487	0.088672	-2.091840	0.0386
VAIC X_3	0.013745	0.002961	4.642679	0.0000

Table 10 shows that carbon emission disclosure has a t-statistic of 1.1104 with a probability value of 0.2691, suggesting that carbon emission disclosure does not have a significant effect on firm value. Meanwhile, Environmental Performance (PROPER) shows a t-statistic of 2.0918 with a probability value of 0.0386, indicating a negative and statistically significant effect on firm value. Furthermore, Intellectual Capital (VAIC) has a t-statistic of 4.6427 with a probability value below 0.001, demonstrating a positive and statistically significant effect on firm value. These findings indicate that intellectual capital plays a significant role in enhancing firm value, whereas environmental performance may be perceived differently by investors in the short term.

4.4.2 Coefficient of Determination (Adjusted R-squared)

Table 11. Coefficient of determination (adjusted R-squared)

R-squared	0.183362
Adjusted R-squared	0.162422

Table 11 shows the regression model produces an Adjusted R^2 of 0.1624, indicating that carbon emission disclosure, environmental performance, and intellectual capital jointly explain approximately 16.24% of the variation in firm value. The remaining 83.76% was explained by other variables not included in the present model. This finding suggests that firm value is influenced by various other internal and external factors beyond sustainability practices and intellectual capital efficiency.

4.4.3 Overall Model Significance (F-test)

Table 12. F-test results

F-statistic	8.756771
Prob(F-statistic)	0.000028

Table 12 shows the regression model generated an F-statistic of 8.7568 with a probability value of 0.000028, which was well below the 5% significance level. Therefore, the three independent variables jointly exert a statistically significant effect on firm value, confirming the statistical validity of the proposed regression model. This result indicates that the combination of carbon emission disclosure, environmental performance, and intellectual capital provides meaningful explanatory power in determining variations in firm value.

4.5 Discussion

4.5.1 The Effect of Carbon Emission Disclosure on Firm Value

The empirical findings indicate that carbon emissions disclosure does not have a statistically significant effect on firm value. Therefore, H_1 is rejected. Although the estimated regression coefficient is positive, its magnitude is insufficient to exert a meaningful influence on investors' valuation decisions. One possible explanation is that carbon emission disclosure remains largely voluntary for Indonesian listed companies. Consequently, investors may not perceive carbon-related disclosures as a critical source of information capable of influencing a firm's future profitability or market valuation. Instead, investment decisions continue to rely primarily on traditional financial indicators rather than on voluntary environmental disclosures.

From the perspective of legitimacy theory, carbon emission disclosure represents a strategic effort by companies to align their business activities with prevailing social expectations regarding environmental responsibility. However, the insignificant relationship observed in this study suggests that such disclosures primarily generate symbolic legitimacy rather than substantive legitimacy; that is, disclosure functions as an impression-management tool rather than as a credible signal of underlying environmental or financial performance. This distinction is theoretically important because legitimacy theory does not assume that all legitimation strategies are equally effective; rather, symbolic disclosure is expected to influence stakeholder perceptions only when it is perceived as credible and substantively linked to firm behavior. In the context of voluntary, self-reported carbon disclosure without third-party assurance, investors may reasonably discount its informational value, which is consistent with the insignificant result found here.

This finding implies that carbon disclosure has not yet become a decisive factor in the Indonesian capital market. Market participants may still perceive sustainability reporting as a compliance-oriented activity or reputational strategy rather than a value-enhancing corporate practice. Consequently, voluntary carbon disclosure alone appears to be insufficient to increase firm value. This result is consistent with [Anggita and Suhaidar \(2022\)](#), who attributed the insignificant effect to Indonesian investors' relatively low sensitivity to decarbonization issues, as well as [Ramdani and Nugraha \(2024\)](#), who similarly found that voluntary environmental disclosures in emerging markets

are not yet fully internalized by investors due to weak enforcement and low disclosure credibility. Conversely, this finding contrasts with that of [Kurnia and Putra \(2020\)](#), who documented a positive and significant relationship. This contrast may be explained by differences in sample composition and disclosure assurance practices, such as studies reporting a significant positive effect often examine firms with third-party verified sustainability reports, whereas the present sample predominantly relies on self-reported, non-assured disclosures, reinforcing the argument that disclosure credibility, rather than disclosure quantity alone, may be the decisive factor shaping the disclosure value relationship.

4.5.2 The Effect of Environmental Performance on Firm Value

The empirical results demonstrate that environmental performance negatively and significantly affects firm value. Accordingly, H_2 , although directionally opposite to expectations, is statistically supported. This finding presents an interesting perspective on how investors evaluate corporate environmental responsibility. During the 2022–2024 observation period, most sampled firms consistently maintained blue, green, or gold PROPER ratings, indicating relatively strong environmental performance. Nevertheless, despite these favorable ratings, Tobin's Q fluctuated and, in several cases, declined over time.

This unexpected negative relationship can be explained through several complementary theoretical lenses beyond legitimacy theory alone. First, drawing on the trade-off theory of corporate social responsibility, achieving and maintaining higher PROPER ratings requires substantial ongoing investment in pollution control technology, environmental management systems, and compliance monitoring. In capital-intensive energy sector firms, these costs are unlikely to be fully offset by short-term revenue gains, meaning that superior environmental performance may coincide with reduced short-term profitability, a cost that the market, particularly in a relatively short-horizon-oriented capital market such as Indonesia's, appears to price negatively. Second, this finding can be interpreted through the lens of overinvestment or greening beyond compliance concerns, investors may perceive environmental expenditures that exceed what is strictly necessary for regulatory compliance as a form of managerial discretion that does not directly serve shareholder wealth maximization, consistent with agency theory concerns about the allocation of free cash flow toward non-core, non-financial objectives. Third, from a signaling perspective, because PROPER ratings are publicly available and relatively homogeneous among large energy firms as reflected in the narrow range of blue-to-gold ratings observed in the sample, high environmental performance may no longer function as a differentiating signal, instead, it may simply be interpreted by investors as the cost of maintaining a license to operate rather than as an indicator of superior future performance.

These findings suggest a divergence between the managerial and investor perspectives. Corporate management generally considers environmental performance an essential component of long-term business sustainability and regulatory compliance. In contrast, investors may interpret expenditures associated with environmental initiatives as additional operational costs that reduce short-term profits and shareholder returns. Consequently, improvements in environmental performance may reduce short-term financial efficiency, thereby lowering firm value.

From the standpoint of legitimacy theory, companies undertake environmental initiatives to obtain and maintain social legitimacy by demonstrating compliance with environmental regulations and societal expectations. However, the results indicate that achieving higher PROPER ratings alone does not necessarily translate to higher market valuations. This suggests a boundary condition of legitimacy theory, legitimacy-seeking behavior enhances firm value only when the market perceives a direct link between legitimacy and future economic benefits. When environmental compliance is perceived as a regulatory obligation rather than a source of competitive advantage, the theorized legitimacy value relationship may not materialize or may even reverse if the associated costs are salient to investors. Investors appear to perceive environmental certification primarily as evidence of regulatory compliance rather than as an indicator of superior corporate performance that can generate additional economic value.

This finding supports the argument that the market may prioritize immediate financial performance over long-term environmental goals. Although environmental responsibility strengthens corporate legitimacy, the associated implementation costs may outweigh its perceived economic benefits from the investors' perspective. These findings are consistent with [Alzura \(2025\)](#), who similarly reported that PROPER-based environmental performance does not generate positive market sentiment, and align more broadly with studies conducted in emerging markets showing that environmental compliance costs can outweigh reputational benefits in the short term. This result diverges from those of [Mardiana and Wuryani \(2019\)](#), [Sapulette and Limba \(2021\)](#), and [Budiharjo \(2019\)](#), who reported positive effects. A plausible explanation for this divergence lies in sectoral differences, such as prior studies documenting positive effects were largely conducted on more heterogeneous, cross-sectoral samples, where variation in PROPER ratings was wider such as ranging from red to gold, allowing the market to meaningfully differentiate between poor and strong environmental performers. In the present energy sector-specific sample, where most firms cluster within the blue to gold range, the restricted variation in environmental performance may limit the market's ability to reward incremental improvements, while the associated compliance costs remain fully priced in, offering a sector-specific explanation for why the relationship reverses in this context. Overall, the evidence suggests that the financial costs associated with environmental management may temporarily offset the potential reputational benefits of improved environmental performance.

4.5.3 The Effect of Intellectual Capital on Firm Value

The regression results reveal that intellectual capital has a positive and statistically significant effect on firm value. Therefore, H_3 is supported. These findings indicate that the effective management of knowledge-based intangible assets plays a vital role in enhancing market valuation. The positive regression coefficient suggests that improvements in intellectual capital efficiency, including the effective utilization of human capital, structural capital, and capital employed, significantly contribute to increasing firm value.

According to legitimacy theory, companies that effectively manage and disclose their intellectual capital are perceived as professionally managed, innovative, and transparent. These characteristics strengthen corporate legitimacy by signaling superior governance quality, sustainable competitive advantage, and long-term growth potential. As a result, investors respond positively by increasing the demand for the company's shares, leading to higher market valuation.

Unlike environmental expenditures, which are often perceived as short-term costs, investments in intellectual capital are generally regarded as strategic investments capable of generating sustainable competitive advantages. This distinction is theoretically consistent with the contrasting findings for H_1 and H_2 in this study, such as while carbon disclosure and environmental performance are largely externally oriented and compliance-driven, intellectual capital reflects internally generated efficiency that is more directly and immediately linked to a firm's earning capacity, making it more readily observable and priceable by investors through conventional financial indicators such as profitability and asset turnover embedded in the VAIC™ components. Strong intellectual capital enhances operational efficiency, stimulates innovation, improves profitability, and reduces business risk, thereby increasing investors' confidence in the firm's future performance.

These findings further indicate that investors increasingly recognize the importance of intangible assets, alongside conventional physical assets. Knowledge, innovation, organizational capability, and human expertise are essential drivers of corporate competitiveness in the modern business environment. The findings of this study are consistent with those of [Gaol and Irawati \(2021\)](#), who concluded that intellectual capital significantly strengthens both corporate fundamentals and market value. This convergence across sectors suggests that, unlike environmental performance, the value relevance of intellectual capital may be relatively stable across industry contexts. However, this result contrasts with [Azhari and Hasibuan \(2023\)](#), who found no significant association; this discrepancy may be attributable to differences in firm maturity or capital intensity across samples, as the value-generating role of intellectual capital may be more pronounced in sectors such as energy, which are undergoing active transformation toward more knowledge- and technology-intensive

operations. Therefore, effective intellectual capital management remains a key strategic resource for sustaining competitive advantages and enhancing firm value.

5. CONCLUSIONS

5.1 Conclusion

This study examined the effects of carbon emission disclosure, environmental performance, and intellectual capital on the firm value of energy sector companies listed on the Indonesia Stock Exchange during 2022–2024. The findings show that carbon emission disclosure has no significant effect on firm value, environmental performance has a negative and significant effect, and intellectual capital has a positive and significant effect on firm value. These results indicate that, within the Indonesian energy sector, investors place greater weight on the efficient management of knowledge-based resources than on environmental disclosure or compliance-driven environmental initiatives when assessing firm value. Overall, the study highlights intellectual capital as a more consistent driver of firm value in this context, while environmental-related variables show mixed and, in the case of environmental performance, counterintuitive effects.

5.2 Research Limitations

This study had several limitations. First, the sample is restricted to energy sector companies listed on the IDX during 2022–2024, limiting the generalizability to other industries or periods. Second, the relatively limited number of firm-year observations reflects constraints on the availability of sustainability reports and financial data. Third, carbon emission disclosure was measured based on voluntary, self-reported sustainability reports, which vary in completeness and consistency across firms.

5.3 Suggestions and Directions for Future Research

Future research should extend this model to other industrial sectors and longer observation periods and employ more comprehensive and standardized sustainability data sources, such as Bloomberg ESG or Thomson Reuters, to improve the consistency and generalizability of carbon disclosure measurements.

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AUTHOR CONTRIBUTIONS

RFA contributed to the conceptualization, methodology development, data collection, data analysis, literature review, and preparation of the initial manuscript draft. YY contributed to research supervision, validation, critical review, and revision of the manuscript to improve its academic quality. Both authors contributed to the interpretation of the findings, approved the final version of the manuscript, and are accountable for the integrity and accuracy of the research.

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