

International Journal of Energy Economics and Policy

ISSN: 2146-4553

available at http: www.econjournals.com

International Journal of Energy Economics and Policy, 2026, 16(6), 67-77.

Environmental Costs, Carbon Emission Disclosure and Corporate Financial Performance: Evidence from the South African Energy Sector

Makhathini Lungani Rudolph[1]*, Kansilembo Aliamutu[2]

[1]Department of Accounting and Law, Mangosuthu University of Technology, Umlazi, South Africa, [2]Department of Auditing, College of Accounting Sciences, Pretoria, South Africa. *Email: lunganim@mut.ac.za

Received: 03 August 2026 **Accepted:** 11 October 2026 **DOI:** https://doi.org/10.32479/ijeep.25096

ABSTRACT

The escalation of climate change and heightened environmental regulations have amplified the necessity for companies, especially those in carbon-heavy sectors, to enhance their environmental management and climate-related reporting. This study investigates the correlation between carbon emission disclosure (CED), environmental costs (ENV-COST), and financial performance in energy-sector companies listed on the Johannesburg stock exchange (JSE). The study uses a quantitative methodology and uses secondary data sourced from business annual reports, integrated reports, and sustainability reports. The empirical investigation relies on 219 observations of energy-sector companies listed on the JSE. Financial performance is evaluated through return on assets (ROA), carbon emission disclosure is gauged using a disclosure index, and environmental costs are quantified by reported environmental expenditures. Descriptive statistics and multiple regression analysis are utilized to investigate the correlations among the variables. The results indicate that carbon emission disclosure is inversely and statistically significantly correlated with financial performance ($\beta = -0.729$; $P < 0.002$). Environmental costs exhibit a positive and statistically significant correlation with financial performance ($\beta = 0.163$; $P < 0.002$). The comprehensive regression model has statistical significance ($F = 28.82$; $P < 0.001$) and accounts for almost 37% of the variance in financial performance ($R^2 = 0.37$; adjusted $R^2 = 0.36$). The results indicate that disclosing carbon emissions could create immediate financial strains or expose environmental hazards, while environmental investments may yield operational, risk-management, and strategic advantages that enhance financial outcomes. The study enhances the field of environmental accounting by illustrating that environmental transparency and investment can yield disparate financial outcomes in a carbon-heavy developing market setting.

Keywords: Environmental Expenditures, Environmental Costs, Carbon Emission Disclosure, Financial Performance, Energy firms, Return on Assets
JEL Classifications: Q56, M41, Q54, G32

1. INTRODUCTION

Climate change has become one of the most critical environmental and economic obstacles confronting economies and enterprises globally. Its repercussions transcend environmental cost, influencing fiscal stability, investment choices, corporate risk assessment, and enduring company strategies (Bhana et al., 2023). Greenhouse gas (GHG) emissions, especially carbon dioxide (CO_2), significantly contribute to global warming and pose considerable transition and physical hazards for carbon-heavy sectors (Chen et al., 2014). These hazards are especially significant for the energy industry, as firms face environmental regulations, evolving energy technology, carbon-associated costs, and mounting pressure to shift toward more sustainable firm models (Fauziah and Puspita, 2024). As a result, corporate performance is progressively evaluated not solely on profitability but also

This Journal is licensed under a Creative Commons Attribution 4.0 International License

on the efficacy with which companies recognize, manage, and convey their environmental and climate-related risks (Filbeck and Gorman, 2004). The escalating incorporation of environmental, social, and governance (ESG) factors into investment choices has amplified the significance of environmental transparency and corporate sustainability initiatives (Gholami, 2022).

The South African context serves as a crucial backdrop for analyzing these advancements due to the nation's historically carbon-heavy energy framework and the considerable economic significance of the energy industry (Ifurueze et al., 2013). Energy firms encounter the difficulty of sustaining fiscal performance while addressing climate-related hazards, environmental responsibilities, and the shift toward a low-carbon economy (Jasch, 2003). For firms traded on the Johannesburg stock exchange (JSE), sustainability data has thus gained heightened significance for investors and other interested parties. The JSE launched its Sustainability and Climate Disclosure Guidance in 2022 to enhance transparency and governance, offering listed firms' direction on ESG and climate-related reporting pertinent to the South African landscape (Mohammad et al., 2023). The directive pertains to climate-related data, encompassing greenhouse gas emissions, and urges firms to furnish decision-relevant information to investors and other interested parties.

In this context, carbon emission disclosure (CED) has emerged as a crucial element of corporate environmental reporting (Retief and Chabalala, 2009). Carbon emission reporting furnishes stakeholders with insights into a company's vulnerability to climate-related threats, its greenhouse gas output, and its strategies for addressing climate change (Schaltegger et al., 2017). The JSE's climate disclosure guidelines explicitly highlight greenhouse gas emissions as a crucial aspect of climate-related reporting, emphasizing the necessity of reporting Scope 1 and Scope 2 emissions, while also suggesting the inclusion of significant Scope 3 emissions when relevant (Schoenmaker and Schramade, 2023). Enhanced transparency could decrease information asymmetry between management and investors, allowing investors to evaluate environmental risks and the company's readiness for a transition to a low-carbon economy (Scupola and Mergel, 2022). Nonetheless, the correlation between carbon emission reporting and financial outcomes remains both theoretically and empirically unclear. Increased transparency can bolster business reputation, elevate stakeholder trust, augment legitimacy, and possibly ease capital acquisition (Le and Nguyen-Phung, 2024). Conversely, comprehensive disclosure could uncover significant environmental hazards and subject enterprises to reputational or regulatory scrutiny, while the compilation and validation of climate data might incur extra costs for organizations (Gabr and Elbannan, 2025).

A pertinent matter pertains to environmental costs, which denote expenditures allocated by companies to avert, manage, or rectify environmental consequences stemming from their activities (Emmanuel et al., 2023). For energy firms, such costs might encompass costs connected to pollution mitigation, waste disposal, environmental cost, energy optimization, emission reduction, environmental adherence, and various sustainability initiatives (Gabr and Elbannan, 2025). Environmental cost may consequently yield two contradictory effects on financial performance. From a strategic viewpoint, environmental cost may represent investments in operational efficacy, cleaner technology, risk mitigation, and enduring sustainability. Such expenditures could mitigate prospective environmental obligations and enhance corporate credibility (Emmanuel et al., 2023). On the other hand, environmental expenditures might elevate operational costs and decrease immediate profitability, especially when the financial advantages of environmental investments are ambiguous or only become apparent after a prolonged duration (Senna and de Araujo Moxotó, 2025). The primary concern is not merely if energy firms face environmental expenses, but rather if these charges are regarded and handled as value-generating investments or profit-decreasing expenditures.

Signalling theory can conceptually elucidate the relationship. Signalling theory can conceptually elucidate the relationship among carbon emission disclosure, environmental cost, and financial outcomes (Emmanuel et al., 2024). Conceptually elucidate the connection among carbon emission disclosure, environmental cost, and financial outcomes. Conceptually elucidate the relationship among carbon emission disclosure, environmental cost, and financial outcomes via signalling theory (Vaicondam et al., 2025). In capital markets marked by information disparity, corporate executives hold greater knowledge regarding the company's environmental costs and sustainability initiatives than outside investors. Carbon emission reporting might thus serve as an indicator of managerial openness and the company's strategy for addressing climate-related risks (Githaiga, 2025). In the same manner, environmental spending might serve as an expensive indicator of authentic environmental dedication, as companies are required to invest monetary resources in environmental safeguarding and adherence (Hou et al., 2025). The reliability of such signals may hold significant importance in the energy sector, as investors are inclined to differentiate between just symbolic sustainability messaging and genuine environmental initiatives (Madwe et al., 2025). The JSE's directives highlight that investors need information that clarifies the impact of climate-related matters on corporations and the measures those corporations are implementing in response. Consequently, the degree and caliber of environmental reporting, along with the magnitude of environmental investment, may affect investors' evaluations of the quality, risk, and long-term viability of energy firms listed on the JSE (Chininga et al., 2024).

The South African energy industry is thus an especially suitable environment for examining these connections. Energy firms function within a landscape marked by considerable environmental vulnerability, extensive capital demands, and a pronounced reliance on energy-associated resources and infrastructure (Bauri et al., 2025). Simultaneously, these corporations encounter escalating demands to tackle climate change and convey their environmental performance to investors in the capital markets. The JSE has clearly established guidance on sustainability and climate disclosures to assist listed companies in adapting to the changing landscape of sustainability reporting, utilizing international frameworks like the Global Reporting Initiative (GRI), Task Force on Climate-related

Financial Disclosures (TCFD), Integrated Reporting Framework, and advancements from the International Sustainability Standards Board (ISSB) (Bharali Saikia and Maji, 2024). This positions JSE-listed energy firms as a suitable empirical context for investigating the relationship between environmental disclosure, environmental spending, and corporate financial performance.

The timeframe of 2021-2025 is notably significant since it includes a phase of considerable economic and sustainability transformations. Organizations encountered financial and operational upheavals due to the COVID-19 epidemic while concurrently grappling with mounting demands to address climate change and the worldwide shift toward more sustainable energy systems. Throughout this timeframe, the expectations for sustainability reporting progressed, as South African publicly traded firms during this timeframe, South African publicly traded firms increasingly faced pressure to improve their climate-related disclosures, leading to a progression in sustainability reporting expectations to enhance their climate-related disclosures. The JSE's sustainability and climate disclosure recommendations, introduced in June 2022, aimed to furnish contextually pertinent recommendations for corporations and enhance the uniformity and applicability of sustainability data available to investors. Thus, analyzing JSE-listed energy firms from 2021 to 2025 offers a chance to evaluate the correlation between environmental transparency, environmental investment, and financial outcomes amid rising sustainability demands and energy transition challenges.

Notwithstanding the increasing significance of environmental reporting in South Africa, substantial empirical deficiencies persist. Initially, the correlation between carbon emission disclosure and financial performance is conceptually unclear, as disclosure can yield reputational and informational advantages while concurrently exposing environmental hazards and incurring reporting expenses. Secondly, the impact of environmental expenses on financial outcomes is ambiguous, since such expenditures could either diminish immediate profits or yield long-term economic advantages via enhanced efficiency, risk mitigation, and stakeholder credibility. Third, there has been a comparatively scant amount of empirical focus on the synergistic impact of carbon emission disclosure and environmental costs specifically in the South African energy industry. This disparity is significant as energy corporations possess markedly different environmental vulnerabilities compared to enterprises in industries with lower carbon intensity. The enclosed research presents empirical data derived from 219 observations and investigates CED2 and ENV-COST2 concerning ROA, highlighting the significance of these variables in the context of the South African energy sector.

This study explores the impact of carbon emission transparency and environmental costs on the financial outcomes of energy businesses listed on the Johannesburg stock exchange from 2021 to 2025. The study enhances the sustainability accounting discourse by investigating the relationship between environmental transparency, environmental expenditure, and business financial performance in a carbon-heavy industry inside an emerging market. The study further broadens the use of signalling theory by investigating whether environmental disclosures and genuine environmental commitments serve as indicators of corporate quality for investors. The results can aid managers of JSE-listed energy firms in assessing whether environmental disclosure and expenditure should be regarded mainly as compliance obligations or as strategic tools for enhancing long-term company worth. The results may furnish investors with supplementary insights for appraising the environmental hazards and fiscal potential of energy firms, while aiding regulators and standard setters in evaluating the efficacy of climate-related and environmental disclosures within the South African capital market.

2. RESEARCH METHODS

This study uses a quantitative methodology and a causal design to investigate the correlation between carbon emission disclosure (CED), environmental costs (ENV-COST), and Financial Performance in energy-sector firms listed on the Johannesburg stock exchange (JSE) from 2021 to 2025. A quantitative methodology is suitable, as the investigation aims to assess the correlations objectively between the research variables through numerical data and statistical methods. The causal research approach: We utilise the causal research approach to examine whether fluctuations in carbon emission disclosure and environmental costs correlate with changes in corporate financial performance. To explore if fluctuations in carbon emission disclosure and environmental costs correlate with alterations in corporation financial performance (Gündüz and Gündüz, 2025). This methodology aligns with the empirical focus of environmental accounting and sustainability studies, wherein quantitative techniques are frequently utilised to examine the financial consequences of environmental reporting and corporate environmental behaviours (Hurduzeu et al., 2022). The enclosed research also investigates carbon emission disclosure and environmental costs about return on assets within South African energy-sector firms.

The study cohort consists of energy industry firms that are publicly traded on the Johannesburg stock exchange within the 2021-2025 timeframe. The energy sector is chosen due to its considerable vulnerability to carbon emissions, environmental hazards, regulatory obligations, and the shift towards a low-carbon economy. Energy firms are typically capital-intensive, rendering financial performance and the effective use of assets critical factors for both management and investors. The JSE setting is notably pertinent as publicly traded corporations function within a progressively advanced sustainability-reporting framework where investors and other stakeholders demand enhanced information regarding environmental and climate-related risks (Azzahra and Hamzah, 2025). The sampling method uses purposive sampling to select firms that meet specified inclusion criteria. The criteria encompass firms who were listed on the JSE throughout the pertinent observation period and that supplied adequate information in their annual reports, integrated reports, and/or sustainability reports to assess carbon emission disclosure, environmental expenditures, and financial performance. The conclusive dataset consists of 219 observations, aligning with the empirical dataset detailed in the accompanying study.

The study predominantly uses secondary data sourced from publicly accessible corporate reports and financial statements of energy firms listed on the JSE. The pertinent data is derived from corporate annual reports, integrated reports, sustainability reports, and other publicly accessible corporate disclosures for the years 2021-2025. Secondary data are suitable for this research, as they include systematically documented financial and non-financial information that can be consistently measured and compared across different organisations and years. The gathered data encompasses details on carbon emission disclosures, environmental costs, net income, and total assets. The data are then converted into indicators that align with the study factors. The accompanying research likewise recognises carbon emission disclosure (CED2), environmental cost (ENV-COST2), and financial performance assessed using ROA as the key factors in the empirical study (Hyusein and Cek, 2025).

Financial performance serves as the dependent variable in this research and is quantified using return on assets (ROA). ROA is chosen as it evaluates a company's proficiency in using its whole asset portfolio to produce earnings. This metric is especially pertinent to organisations in the energy sector, as these enterprises typically require significant capital outlays for real estate, machinery, infrastructure, and other productive resources. ROA thus serves as a suitable metric for evaluating the correlation between environmental practices, environmental expenditures, and the efficiency with which companies produce financial returns from their asset portfolio. The calculation of ROA is as follows: return on assets (ROA) is calculated by dividing net profit after tax by total assets.

The use of ROA aligns with the empirical framework presented in the accompanying South African research, which identifies LG-ROA as the metric for financial performance. The analytical report indicates 219 observations for the dependent variable, with a mean of −2.12 next to the logarithmic transformation executed on the dataset (Kamugisha and Sun, 2025). The primary independent variable is carbon emission disclosure (CED). Carbon emission disclosure reflects the degree to which a corporation in the energy sector conveys details about its greenhouse gas emissions and associated environmental effects. In the context of the JSE, carbon disclosure ought to be evaluated by a systematic disclosure index grounded in established sustainability-reporting metrics, notably the GRI 305: Emissions framework. The disclosed items may encompass details regarding direct greenhouse gas emissions (Scope 1), indirect energy-related emissions (Scope 2), further indirect emissions (Scope 3), greenhouse gas emission intensity, measures for emission reduction, and other pertinent emissions data.

A content-analysis methodology is used to assess the degree of disclosure. A binary scoring method is used, assigning a score of 1 when a corporation reveals a certain carbon-emission element and 0 when it remains undisclosed. The disclosure score is then determined by the ratio of relevant disclosure items submitted by each corporation (Chawarura et al., 2025). This method offers a structured and impartial way to assess the level of carbon-related transparency among energy firms listed on the JSE. The accompanying research designates CED2 as the variable for carbon-emission disclosure and indicates an average CED2 value of 0.68 from the 219 observations.

The second autonomous variable is environmental costs (ENV-COST). Environmental costs pertain to the financial outlays that organisations face in overseeing, averting, regulating, or alleviating the environmental impacts of their activities. In the energy industry, such expenses may encompass costs associated with pollution prevention and control, waste management, emissions oversight, environmental restoration, conservation efforts, energy efficiency, and adherence to environmental regulations (Shaheen and Qubbaja, 2022). Environmental costs are quantified based on the environmental cost disclosed by individual firms. Due to significant variations in environmental spending among organisations based on their size and operating scale, the disclosed environmental cost figures are adjusted using the natural logarithm. The logarithmic transformation diminishes the impact of outlier data points and promotes a more reliable estimate of the regression model (Nyahuna and Doorasamy, 2022). The accompanying paper presents ENV-COST2 for 219 observations, revealing a mean of 34.15 and a standard deviation of 3.72, signifying considerable variability in environmental cost levels among the observations.

3. ECONOMETRIC MODEL SPECIFICATION

To explore the relationship between carbon emission disclosure, environmental costs and financial performance, the study specifies the following multiple regression model:

$$ROA_{it} = \beta_0 + \beta_1 CED_{it} + \beta_2 ENV\text{-}COST_{it} + \mathcal{E}_{it}$$

Where:
ROA_{it} = Financial performance of firm i in year t;
CED_{it} = Carbon emission disclosure of firm i in year t;
$ENV\text{-}COST_{it}$ = Environmental costs of firm i in year t;
β_0 = Regression constant
β_1 and β_2 = Coefficient measuring the effects of carbon emission disclosure and environmental costs respectively, and
$\mathcal{E}_{it}$ = Error term

The model enables the research to ascertain if increased carbon-emission transparency and elevated environmental expenses correlate with variations in the financial performance of energy firms listed on the JSE. The empirical findings presented indicate a statistically significant coefficient of −0.729 for CED2 and a statistically significant coefficient of 0.163 for ENV-COST2. The comprehensive model is deemed statistically significant, with an R^2 of 0.37 and an adjusted R^2 of 0.36.

3.1. Data Analysis

The collated data is explored by descriptive statistics and inferential statistical methods. Descriptive statistics are initially used to encapsulate the distribution and attributes of the variables, encompassing the minimum, maximum, mean,

and standard deviation. The accompanying paper presents these descriptive data for 219 observations. Prior to estimating the regression model, diagnostic evaluations are performed to see if the data meet the assumptions fundamental to regression analysis (Jain and Malhotra, 2026). These encompass assessments for normalcy, multicollinearity, heteroscedasticity, and autocorrelation. The normality assessment detailed in the accompanying research yields an asymptotic significance value of 0.311, suggesting that the residuals meet the normality requirement. The multicollinearity analysis indicates tolerance values of 0.991 and VIF values of 2.247 for the independent variables, implying that multicollinearity is not a significant concern in the model. The heteroscedasticity assessment yields significant values of 0.939 for CED2 and 0.461 for ENV-COST2, although the Durbin-Watson statistic of 2.165 indicates the absence of substantial autocorrelation.

Hypothesis testing is then conducted utilizing the t-test to assess the separate impacts of carbon emission disclosure and environmental expenses on financial performance. An F-test evaluates if the independent variables collectively account for fluctuations in financial performance. Furthermore, the coefficient of determination (R^2) and the adjusted R^2 are employed to evaluate the explanatory capacity of the regression model. The empirical findings in the accompanying study demonstrate that the regression model is statistically significant overall, as evidenced by an F-statistic of 28.82 and a significance level beneath standard standards. The model accounts for almost 37% of the variance in financial performance, with the corrected R^2 being about 36%.

This data analysis facilitates the study of the relationship between environmental transparency, environmental cost, and the financial performance of energy-sector firms listed on the Johannesburg Stock Exchange. The methodology is especially pertinent to South Africa as energy firms function at the confluence of fiscal viability, environmental cost, and the shift toward a reduced-carbon economy. The study emphasizes the 2021-2025 timeframe, offering current insights into the financial ramifications of carbon-emission transparency and environmental costs in the South African energy industry. The table 1 below unpacks the variables, types, measurement and measurement scales.

4. RESULTS

4.1. Descriptive Analysis

Table 2 displays the descriptive statistics for the 219 observations used in the study, encompassing carbon emission disclosure (CED2), environmental costs (ENV-COST2), and financial performance quantified by the logarithm of return on assets (LG-ROA). The findings indicate that CED2 possesses a mean of 0.68 and a standard deviation of 0.47, with a minimum value of −0.41 and a maximum value of 2.64. The comparatively moderate standard deviation signifies that carbon emission disclosure differs among the surveyed energy-sector companies, yet the negative minimum and a value exceeding one imply that the development or formulation of the CED2 metric must be thoroughly elucidated in the methodology to guarantee theoretical consistency of the disclosure index.

The average environmental cost (ENV-COST2) is 34.15, accompanied by a standard deviation of 3.72, and spans from 27.98 to 39.98. This finding signifies considerable disparities in the extent of environmental spending among the surveyed companies. The disparity is economically justifiable as JSE-listed energy firms significantly vary in operational magnitude, ecological exposure, pollution mitigation obligations, and commitment to environmental stewardship. The mean's comparatively low standard deviation indicates that environmental costs predominantly cluster around their average, despite significant disparities among enterprises. The comparatively low standard deviation relative to the mean indicates that environmental costs. The environmental costs primarily cluster around the average, despite significant disparities among enterprises, as indicated by the comparatively low standard deviation relative to the mean. around the average, despite significant disparities among enterprises. The mean's comparatively low standard deviation indicates that environmental costs predominantly cluster around their average, despite significant disparities among enterprises. Around their average, notwithstanding significant disparities among enterprises.

LG-ROA has an average of −2.12 and a standard deviation of 0.53, with values spanning from −3.00 to −0.35. The negative average

Table 1: Description and measurement of variables

Variable	Type	Measurement	Measurement scale
Financial performance (ROA)	Dependent	Return on assets (ROA), calculated as net profit after tax % total assets. In the empirical dataset, ROA is transformed into its logarithmic form (LG-ROA)	Ratio
Carbon emission disclosure (CED)	Independent	Measured using a carbon emission disclosure index based on GRI 305: Emissions. Each applicable disclosure item receives 1 if disclosed and 0 otherwise. The index is calculated as the total disclosed items by the total applicable disclosure items.	Index/Ratio
Environmental costs (ENV-COST)	Independent	Measured using the firm's reported cost on environmental management. Including pollution prevention/control, waste management, emission control, environmental rehabilitation and environmental protection activities. This value is transformed using the natural logarithm (Ln)	Ratio
Firm size	Control	Natural logarithm of total assets (Ln total assets)	Ratio
Leverage	Control	Total liabilities divided by total assets (Total liabilities % total assets)	Ratio
Firm age	Control	Number of years from the company's establishment to the year of observation	Ratio
Sales growth	Control	Annual change in sales/revenue calculated as ($Sales_t$−$sales_{t-1}$) % $Sales_{t-1}$	Ratio
Liquidity	Control	Current assets divided by current liabilities (Current assets % Current Liabilities)	Ratio

Table 2: Descriptive test

Indicator	N	Min	Max	Mean	Std.dev
CED2	219	−0.41	2.64	0.68	0.47
ENV-COST2	219	27.98	39.98	34.15	3.72
LG-ROA	219	−3.00	−0.35	−2.12	0.53

suggests that, after applying the logarithmic transformation described in the research, financial performance predominantly falls below zero across the dataset. The negative average indicates that, following the logarithmic transformation detailed in the research, financial performance predominantly falls below zero throughout the data below zero throughout the data set. The standard deviation of 0.53 signifies a moderate variability in financial outcomes.

4.2. Classical Assumption Test

Table 3 presents the one-sample Kolmogorov-Smirnov assessment for the unstandardised residuals. The examination is based on 219 observations, with the residuals exhibiting a mean close to 0.000 and a standard deviation of 0.475. The utmost absolute difference is 0.164, with the positive and negative differences being 0.164 and −0.163, respectively. The Kolmogorov-Smirnov test yields an asymptotic significance value of 0.311. Given that this probability value is above the traditional 5% significance threshold, the null hypothesis asserting that the residuals adhere to a normal distribution remains unchallenged. Consequently, the residuals may be considered to follow a normal distribution. This discovery endorses the application of the regression model, as the normality assumption of the residuals remains intact. As a result, the projected coefficients and their corresponding significance assessments can be understood without indications of substantial non-normality in the model's residuals.

Table 4 evaluates the presence of multicollinearity between carbon emission disclosure (CED2) and environmental costs (ENV-COST2). Both independent variables exhibit a tolerance value of 0.991 and a variance inflation factor (VIF) of 2.247. These findings indicate an absence of concerning multicollinearity. The VIF readings are far lower than the typical threshold of 10, yet the tolerance levels are above the generally accepted minimal level of concern. The findings suggest that CED2 and ENV-COST2 do not display an excessive linear correlation that could compromise the stability of the computed regression coefficients. This is significant, as pronounced multicollinearity can amplify standard errors and hinder the ability to differentiate the individual impacts of the explanatory factors on financial performance. The VIF of 2.247 indicates that the independent variables possess some common information, although not to a degree that would jeopardize the regression estimates. The coefficient outcomes presented in the same table indicate that CED2 possesses a negative and statistically significant coefficient of −0.729, but ENV-COST2 exhibits a positive coefficient of 0.163. The main objective of Table 4 is diagnostic rather than for hypothesis testing; thus, these coefficients must be analyzed thoroughly in conjunction with the formal regression findings in Table 7.

Table 5 displays the results of the heteroscedasticity examination for the regression model. The assessment evaluates if the

Table 3: Results of normality test (One-sample Kolmogorow-Smirnov)

	Unstandardized residual
N	219
Normal parameters[a,b]	
Mean	0.000000
Standard deviation	0.47518238
Most extreme differences	
Absolute	0.164
Positive	0.164
Negative	-0.163
Asymp. sig. (2-tailed)[c]	0.311[d]

[a]Test distribution is normal. [b]Calculated from data. [c]Lilliefors significance correction. [d]This is a lower bound of the true significance

variability of the residuals alters consistently among observations. For CED2, the significance level is 0.939, but ENV-COST2 exhibits a significance level of 0.461. Both significance values are above the 5% limit. Consequently, the null hypothesis asserting continuous error variance remains unrefuted. This suggests that there is no statistically significant evidence of heteroscedasticity linked to either carbon emission disclosure or environmental costs. The results indicate that the residual variance remains rather stable throughout the data, fulfilling the homoscedasticity criterion necessary for standard regression analysis. The lack of considerable heteroscedasticity enhances trust in the accuracy of the computed standard errors and significance assessments. Consequently, the regression results are consistent. Disparities in the variance of the residuals among observations are unlikely to influence the regression results. by consistent disparities in the variance of the residuals among observations.

Table 6 presents the Durbin-Watson statistic to assess the presence of autocorrelation in the regression residuals. The model exhibits an R-value of 0.627, an R^2 of 0.378, an adjusted R^2 of 0.364, a standard error of the estimate of 0.47863, and a Durbin-Watson statistic of 2.165.

The Durbin-Watson statistic of 2.165 approximates the reference value of 2.0, suggesting that there is no substantial indication of first-order autocorrelation in the residuals. This diagnostic outcome is significant, as autocorrelation may lead to ineffective estimations and could undermine traditional statistical reasoning. The findings indicate that the residuals are adequately independent for the regression analysis. The R^2 value of 0.378 signifies that roughly 37.8% of the fluctuations in financial performance (ROA) are accounted for by the explanatory variables in the model, whilst the adjusted R^2 of 0.364 reveals that about 36.4% is still elucidated after accounting for the number of predictors. The minor disparity between R^2 and adjusted R^2 indicates that the explanatory variables contribute significant explanatory strength without much negative from model intricacy.

Table 7 displays the regression findings that analyse the impact of carbon emission disclosure (CED2) and environmental costs (ENV-COST2) on financial success, quantified by return on assets (ROA). The findings indicate that carbon emission disclosure exhibits a detrimental and statistically significant correlation with financial performance, characterised by a coefficient of

Table 4: Multicollinearity test

Model unstandardised B	Coefficients std. error	Standardised coefficients beta	T	Sig	Collegiality tolerance	Vif. statistics	VIF.
1 (Androniceanu et al., 2023)	−2.951	0.431		−6.858	<0.002		
CED2	−0.729	0.251	−0.642	−6.975	<0.002	0.991	2.247
Env-Cost2	0.163	0.126	−428	−4.695	<0.002	0.991	2.247

Table 5: Heteroscedasticity test

Model unstandardised B	Coefficients std. error	Coefficients beta	Standardised coefficients beta	t	Sig.
1 (Androniceanu et al., 2023)	0.597	0.286		3.581	0.125
CED2	−0.125	0.174	−0.133	−0.328	0.939
Env-Cost2	−0.119	0.118	−0.188	−0.849	0.461

Dependent variable: ABC-RES

Table 6: Autocorrelation test

Model	R	R-square	Adjust R-square	Standard error of the estimate	Durbin-Waston
1	0.627[a]	0.378	0.364	0.47863	2.165

−0.729, a standard error of 0.215, a standardised beta coefficient of −0.642, and a t-statistic of −6.876 at a significance threshold of $P < 0.002$. This discovery suggests that heightened carbon emission transparency correlates with a decline in ROA within the explored South African energy companies. Consequently, the null hypothesis regarding the impact of carbon emission disclosure is dismissed. The notably substantial absolute t-statistic suggests that the association is statistically significant rather than a product of random sampling fluctuations.

The negative coefficient indicates that increased carbon emission transparency could correlate with heightened reporting, measurement, verification, and compliance obligations that incur expenses for companies. For energy firms functioning in a carbon-heavy context, heightened transparency may render environmental hazards and carbon-associated obligations more apparent to investors and other interested parties. Thus, while disclosure can improve openness, it may also uncover environmental vulnerabilities or subject companies to increased regulatory and reputational examination. The discovery indicates that carbon disclosure does not automatically result in prompt financial advantages for companies in the energy sector.

Environmental costs exhibit a positive and statistically significant correlation with financial performance. The coefficient is 0.163, accompanied by a standard error of 0.126, a standardised beta of 0.428, and a t-statistic of 4.695, with $P < 0.002$. As a result, the null hypothesis about environmental costs is dismissed in favour of a positive correlation. This finding suggests that increased environmental spending correlates with enhanced financial outcomes for the enterprises studied.

The positive correlation indicates that environmental spending could serve not only as a cost of operation but also as a tactical investment. Investing in pollution prevention, environmental safeguarding, waste management, emission regulation, rehabilitation, and adherence to environmental standards could enhance operational efficacy, mitigate environmental hazards and liabilities, and bolster business credibility. These positive could ultimately enhance asset utilisation and financial performance. The comprehensive regression model exhibits statistical significance, evidenced by an F-statistic of 28.82 with $P < 0.001$.

This suggests that CED2 and ENV-COST2 collectively offer statistically significant explanatory influence on fluctuations in ROA. The model's R^2 of 0.37 indicates that approximately 37% of the fluctuations in financial performance can be explained by its factors. The model's R^2 of 0.37 indicates that its factors explain approximately 37% of the fluctuations in financial performance. by its factors. The modified R^2 of 0.36 signifies that roughly 36% of the variability is elucidated after considering model intricacy. Consequently, although several firm-specific and macroeconomic elements may affect financial performance, environmental disclosure and associated costs together offer significant explanatory capacity.

5. DISCUSSION

The results offer significant proof of the correlation between ecological practices and financial outcomes for energy-sector companies listed on the Johannesburg Stock Exchange. The findings indicate that carbon emission disclosure and environmental costs exhibit inverse correlations with financial performance (Nuhu and Alam, 2024). Carbon emission disclosure exhibits an inverse relationship with ROA, whereas environmental expenditures demonstrate a direct correlation with ROA. This differentiation is significant because it implies that environmental transparency and environmental expenditure should not be viewed as synonymous aspects of corporate environmental accountability (Dzomonda, 2022).

The inverse and statistically meaningful correlation between carbon emission disclosure and financial performance indicates that increased disclosure correlates with decreased ROA among the enterprises studied. One potential rationale is that carbon disclosure incurs prompt economic and administrative costs without guaranteeing corresponding short-term financial gains (Ning et al., 2024). Companies could face costs associated with data acquisition, carbon assessment, verification, reporting frameworks, specialized knowledge, and regulatory adherence. Moreover, improved transparency could reveal to investors and

Table 7: Results of the F, R^2 test and t-test

Variables	B	Std. error	Beta	t	Sig.	Data
Androniceanu et al., 2023	−2.95	0.43		−6.858	0.00	
CED2	−0.729	0.215	−0.642	−6.876	<0.002	Rejected
ENV-COST2	0.163	0.126	0.428	4.695	<0.002	Accepted
F count	28.82				0.00***	Fit Model
R-square	0.37					
Adjusted R^2	**0.36**					

Dependent variable: ROA. Data: CED2: Carbon emission disclosure, ENV-COST2: Environmental cost 2

authorities details regarding environmental hazards and carbon-heavy activities. For companies in South Africa's energy industry, where environmental and carbon concerns are notably pronounced, enhanced openness could consequently provide immediate financial repercussions (Ghosh et al., 2024).

This discovery also offers a significant elucidation through signalling theory. Carbon emission reporting can act as an indicator of management openness and environmental accountability. Nonetheless, the efficacy of such a signal is contingent upon the stakeholders' interpretation of the provided information (Le, 2024). When disclosure indicates significant carbon exposure, environmental responsibilities, or insufficient advancement in emissions reduction, investors may perceive the signal negative. As a result, mere transparency may not enhance financial performance. The economic value of disclosure may hinge on the presence of credible environmental enhancements and proficient environmental stewardship (Xia et al., 2025). The paper establishes signalling theory as the foundational notion for comprehending how environmental information can affect stakeholders' evaluations of a company's quality and risk.

The affirmative and statistically meaningful correlation between environmental costs and ROA yields a divergent outcome. The discovery indicates that companies investing more capital in environmental management can attain superior financial outcomes. Investment in environmental initiatives can enhance industrial efficacy, minimize waste, reduce pollution, optimize energy use, and ensure superior environmental adherence (Dan et al., 2023). These advantages might mitigate any environmental risks and operational interruptions while enhancing connections with stakeholders. In this context, environmental expenditures could be viewed as strategic investments instead of merely inescapable costs.

The positive correlation is especially pertinent to the energy industry, since energy firms function within a context marked by significant environmental hazards and regulatory obligations. Investing in environmental initiatives can assist companies in mitigating risks that could lead to fines, cleanup costs, reputational harm, or operational disruptions (Noja et al., 2023). The findings bolster the claim made in the research that environmental investments might yield prolonged economic advantages, despite the initial perception of heightened operational costs.

The aggregated results hold significant ramifications for corporate executives. They propose that revealing environmental data and allocating resources to environmental initiatives provide varying financial outcomes. Managers ought to refrain from perceiving environmental disclosure solely as a compliance-driven endeavor. Disclosure must be paired with significant environmental initiatives that exhibit enhancements in environmental performance (Tarmizi and Brahmana, 2023). When transparency is backed by genuine environmental investment, companies may be more adept at transforming environmental accountability into stakeholder trust, operational effectiveness, and sustained financial worth.

The results are significant to investors. Investors in energy companies listed on the JSE may have to differentiate between the volume of environmental data revealed and the actual environmental performance of a company (Haibo and Manu, 2022). A higher level of transparency does not necessarily mean better financial results. On the other hand, environmental spending could signify companies' dedication to addressing environmental hazards and enhancing operational sustainability. Consequently, investors ought to evaluate both environmental transparency and genuine environmental expenditures while analyzing the long-term risks and financial outlook of energy-sector companies (Bilivogui and Iqbal, 2025).

The findings underscore the necessity for regulators and standard setters to guarantee that climate and carbon disclosures are meaningful for decision-making, consistent, and adequately comparable among companies (Desai et al., 2022). The JSE's Sustainability and Climate Disclosure Guidance offers a crucial institutional framework for enhancing climate-related reporting, especially concerning greenhouse gas emissions. Enhanced transparency should, in an ideal scenario, be paired with incentives for companies to implement meaningful environmental enhancements rather than simply augmenting the quantity of disclosed information (Emmanuel et al., 2023).

6. CONCLUSION AND RECOMMENDATIONS

This study investigated the correlation between carbon emission disclosure, environmental costs, and financial outcomes among energy-sector companies listed on the Johannesburg Stock Exchange. The study utilised 219 observations and applied quantitative analysis to examine the relationship between environmental transparency, environmental expenditures, and returns on assets. The empirical findings indicate that the two environmental factors have varying correlations with financial performance. The findings demonstrate that carbon emission disclosure exhibits a negative and statistically significant correlation with ROA, whereas environmental costs show a negative and statistically significant correlation with ROA, whereas

environmental costs show a positive and statistically significant correlation with ROA. The results indicate that increased carbon emission transparency could create immediate financial strain or reveal environmental hazards that negatively affect financial outcomes. Conversely, environmental spending seems to correlate with enhanced financial outcomes, indicating that investment in environmental stewardship may yield operational, reputational, and risk management advantages.

The statistically significant F-test further illustrates that the explanatory factors together account for variances in financial performance. The model exhibits a modest level of explanatory capability, indicated by an R^2 of roughly 37% and an adjusted R^2 of 36%. The diagnostic assessments detailed in the research additionally furnish credible proof that the regression model is free from significant issues of normality, multicollinearity, heteroscedasticity, or autocorrelation. The study thus determines that environmental accountability should not be viewed solely as a monetary burden. The study thus concludes that we should not view environmental cost solely as a monetary burden, solely as a monetary encumbrance. Companies should differentiate between environmental reporting and environmental expenditure. Although mere disclosure could yield negative financial consequences in the short run, genuine investment in environmental management could enhance financial outcomes. The results underscore the necessity of incorporating environmental factors into corporate strategy instead of viewing them merely as compliance obligations.

7. RECOMMENDATION

7.1. Recommendations for Energy-sector Managers

Energy-sector companies must incorporate environmental investments into their long-term strategies and financial frameworks. The positive correlation between environmental expenditures and ROA suggests that well-managed environmental investments can yield economic advantages. Companies ought to emphasise funding for pollution mitigation, energy optimisation, emissions abatement technologies, waste disposal, and environmental restoration.

Managers must also ensure that carbon emission reporting is accurate and comprehensive. Managers must also ensure that meaningful environmental initiatives support carbon emission reporting. by meaningful environmental initiatives. The adverse correlation between CED and ROA indicates that mere disclosure could not yield prompt financial advantages. Organisations ought to transcend mere compliance-focused reporting and utilise transparency to showcase quantifiable advancements in emissions control and environmental performance.

7.2. Recommendations for Investors

Investors should evaluate environmental data alongside real environmental expenditures and business financial outcomes. An increased degree of carbon disclosure should not be construed as an indication of enhanced financial performance. Investors want to assess if the stated environmental pledges are backed by quantifiable investments and enhancements in environmental governance.

7.3. Recommendations for Regulators and Standard Setters

Regulatory bodies and standard-setting organisations must persist in enhancing the uniformity, comparability, and dependability of carbon-emission disclosures among companies listed on the JSE. Enhanced uniformity in reporting Scope 1, Scope 2, and relevant Scope 3 emissions would help investors make more meaningful comparisons among firms. The regulatory structure needs to promote the linkage between environmental disclosures and quantifiable environmental results.

7.4. Recommendations for Corporate Reporting

Organisations should enhance the incorporation of environmental data into annual reports, integrated reports, and sustainability reports. Environmental costs should be disclosed publicly when significant, allowing stakeholders to differentiate between costs associated with environmental compliance, pollution mitigation, rehabilitation, and environmental enhancement.

7.5. Recommendations for Future Research

Future research should broaden the study beyond ROA by integrating several indicators of financial performance, including ROE, Tobin's Q, and market-orientated performance metrics. Subsequent studies might include supplementary control variables, analyse extended timeframes, juxtapose energy companies with other sectors, and explore whether factors such as firm size, leverage, corporate governance, or environmental performance influence the correlation between environmental practices and financial outcomes.

REFERENCES

Androniceanu, A., Sabie, O.M., Georgescu, I., Drugău-Constantin, A.L. (2023), Main factors and causes that are influencing the digital competences of human resources. Administratie si Management Public, 41, 26-53.

Azzahra, A., Hamzah, R.S. (2025), Carbon emissions disclosure in Asia-pacific: The role of carbon and financial performance in high-impact sectors. Jurnal Akuntansi Bisnis, 18, 209-230.

Bauri, S., Mondal, A., Fatma, U. (2025), Impact of climate risk on financial performance-evidence from select energy companies from select G-20 countries. International Journal of Energy Sector Management, 19, 241-268.

Bhana, A., Suknunan, S., Aliamutu, K.F. (2023), The impact of environmental costs on financial performance: An explorative analysis of two plastic companies. Environmental Economics, 14, 13-23.

Bharali Saikia, M., Maji, S.G. (2024), Corporate carbon emissions, science-based targets initiatives and firm performance: Evidence from India. International Journal of Law and Management, 68, 22-42.

Bilivogui, P., Iqbal, M.A. (2025), Do ESG scores matter? An empirical analysis of corporate financial performance in BRICS economies. Environmental Research Communications, 7, 065023.

Chawarura, W.I., Sibanda, M., Mamvura, K. (2025), The impact of ESG on the financial performance of johannesburg stock exchange-listed companies. Risks, 13, 114.

Chen, X., Cui, Z., Fan, M., Vitousek, P., Zhao, M., Ma, W., Wang, Z., Zhang, W., Yan, X., yang, J. (2014), Producing more grain with lower environmental costs. Nature, 514, 486-489.

Chininga, E., Alhassan, A.L., Zeka, B. (2024), ESG ratings and corporate

financial performance in South Africa. Journal of Accounting in Emerging Economies, 14, 692-713.
Dan, E., Shen, J., Zheng, X., Liu, P., Zhang, L., Chen, F. (2023), Asset structure, asset utilization efficiency, and carbon emission performance: Evidence from panel data of China's low-carbon industry. Sustainability, 15, 6264.
Desai, R., Raval, A., Baser, N., Desai, J. (2022), Impact of carbon emission on financial performance: Empirical evidence from India. South Asian Journal of Business Studies, 11, 450-470.
Dzomonda, O. (2022), Environmental sustainability commitment and access to finance by small and medium enterprises: The role of financial performance and corporate governance. Sustainability, 14, 8863.
Emmanuel, Y.L., Adenikinju, O., Doorasamy, M., Ayoola, T.J., Oladejo, A.O., Kwarbai, J.D., Otekunrin, A.O. (2023), Carbon emission disclosure and financial performance of quoted Nigerian financial services companies. International Journal of Energy Economics and Policy, 13, 628-635.
Emmanuel, Y.L., Doorasamy, M., Kwarbai, J.D., Kolawole, P., Otekunrin, A.O., Osakede, U.A. (2024), Relationship of environmental disclosure of renewable energy, carbon emissions, waste management, water consumption, and banks' financial performance. International Journal of Energy Economics and Policy, 14, 584-593.
Fauziah, D.A., Puspita, D.A. (2024), The effect of carbon emission disclosure and environmental costs on financial performance with environmental performance as a moderating factor. Nominal: Barometer Riset Akuntansi dan Manajemen, 13, 202-211.
Filbeck, G., Gorman, R.F. (2004), The relationship between the environmental and financial performance of public utilities. Environmental and Resource Economics, 29, 137-157.
Gabr, D.H., Elbannan, M.A. (2025), Is it worth it to go green? ESG disclosure, carbon emissions and firm financial performance in emerging markets. Review of Accounting and Finance, 24, 193-217.
Gholami, A. 2022. Corporate environmental, social and governance (ESG) performance disclosure and company's capital cost, idiosyncratic risk and market value [Doctoral thesis, University of Southern Queensland]. USQ Research Repository. Available from: https://research.usq.edu.au/item/q73y9/corporate-environmental-social-and-governance-esg-performance-disclosure-and-company-s-capital-cost-idiosyncratic-risk-and-market-value.
Ghosh, S., Pareek, R., Sahu, T.N. (2024), Do carbon performance and disclosure practices effect companies' financial performance: A non-linear perspective. Asia-Pacific Financial Markets, 31, 733-754.
Githaiga, P.N. (2025), Determinants of carbon emission disclosure among listed firms in the East Africa community partner states. Social Responsibility Journal, 21, 1606-1629.
Gündüz, M., Gündüz, M. (2025), Environmental accounting disclosures and financial performance: Evidence from the banking sector. Sustainability, 17, 3569.
Haibo, C., Manu, E.K. (2022), The impact of banks' financial performance on environmental performance in Africa. Environmental Science and Pollution Research, 29, 49214-49233.
Hou, T.C.T., Tran, N.H., Msefula, G., Dlamini, N.N. (2025), Corporate carbon emissions and firm performance in South Africa. Review of Integrative Business and Economics Research, 14, 55-71.
Hurduzeu, G., Noja, G.G., Cristea, M., Drăcea, R.M., Filip, R.I. (2022), Revisiting the impact of esg practices on firm financial performance in the energy sector: New empirical evidence. Economic Computation and Economic Cybernetics Studies and Research, 56, 37.
Hyusein, A., Cek, K. (2025), ESG strategies and corporate financial performance: A comparison of the US energy and renewable energy industries. International Journal of Energy Sector Management, 19, 977-999.
Ifurueze, M., Lyndon, M., Bingilar, P. (2013), The impact of environmental cost on corporate performance: A study of oil companies in Niger Delta States of Nigeria. Journal of Business and Management, 2, 1-10.
Jain, P., Malhotra, P. (2026), Does national economic development (NED) influence ESG on corporate performance? Evidence from the global cement industry. International Journal of Productivity and Performance Management, 75, 228-263.
Jasch, C. (2003), The use of environmental management accounting (EMA) for identifying environmental costs. Journal of Cleaner Production, 11, 667-676.
Kamugisha, D.K., Sun, H. (2025), Environmental, social, and governance ratings and corporate financial performance: Evidence from emerging economies. Total Quality Management and Business Excellence, 36, 1480-1498.
Le, H., Nguyen-Phung, H.T. (2024), Assessing the impact of environmental performance on corporate financial performance: A firm-level study of GHG emissions in Africa. Sustainable Production and Consumption, 47, 644-654.
Le, L.T. (2024), Impact of environmental, social and governance practices on financial performance: Evidence from listed companies in Southeast Asia. Cogent Business and Management, 11, 2379568.
Madwe, M.C., Nzuza, Z.W., Olarewaju, O.M. (2025), The impact of energy efficiency on financial performance: Evidence from polluters in South Africa. Sustainability, 17, 10630.
Mohammad, W.M.W., Osman, M., Rani, M.S.A. (2023), Corporate governance and environmental, social, and governance (ESG) disclosure and its effect on the cost of capital in emerging market. Asian Journal of Business Ethics, 12, 175-191.
Ning, W., Saeed, U.F., Twum, A.K., Osei, A. (2024), Can ESG disclosures promote firms going concern? Evidence from BRICS countries. Corporate Social Responsibility and Environmental Management, 31, 3792-3803.
Noja, G.G., Cristea, M., Pirtea, M.G., Panait, M., Drăcea, R.M., Abrudan, D. (2023), Drivers of firms' financial performance in the energy sector: A comparative approach between the conventional and renewable energy fields. Engineering Economics, 34, 205-222.
Nuhu, Y., Alam, A. (2024), Board characteristics and ESG disclosure in energy industry: Evidence from emerging economies. Journal of Financial Reporting and Accounting, 22, 7-28.
Nyahuna, T., Doorasamy, M. (2022), Is mandatory ecological information disclosure linked with real ecological performance? Evidence from gauteng local government, South Africa. Journal of Environmental Management and Tourism, 13, 1970-1977.
Retief, F., Chabalala, B. (2009), The cost of environmental impact assessment (EIA) in South Africa. Journal of Environmental Assessment Policy and Management, 11, 51-68.
Schaltegger, S., Burritt, R., Petersen, H. (2017), An Introduction to Corporate Environmental Management: Striving for Sustainability. London: Routledge.
Schoenmaker, D., Schramade, W. (2023), Corporate Finance for Long-Term Value. Berlin: Springer Nature.
Scupola, A., Mergel, I. (2022), Co-production in digital transformation of public administration and public value creation: The case of Denmark. Government Information Quarterly, 39, 101650.
Senna, A.L., De Araujo Moxotó, A.C. (2025), Carbon emissions and financial performance in the Brazilian stock market. Journal of Environmental Management, 377, 124698.
Shaheen, Y., Qubbaja, A. (2022), Environmental, social, corporate governance disclosure and financial performance-evidence from Palestine Exchange (PEX). Middle East Journal Scientific Publishing, 5, 264-282.
Tarmizi, N.F.A., Brahmana, R.K. (2023), Environmental performance,

political connection, and financial performance: Evidence from global oil and gas companies. Environmental Science and Pollution Research, 30, 11081-11098.

Vaicondam, Y., Mustafa, A.M.A.A., Roslan, S.N.M., Ming, K.L.Y. (2025), GHG and carbon emission intensity: Examining their impact on financial performance. International Journal of Energy Economics and Policy, 15, 190-196.

Xia, L., Fatema, N., Rahman, M.M., Hossain, A. (2025), Nexus of environmental management accounting, and carbon emission management on environmental, social, and governance performance: Evidence from symmetrical and asymmetrical approach. Humanities and Social Sciences Communications, 12, 1073.