Environmental Mitigation Financing and Financial Efficiency of Listed Industrial Goods Firms in Nigeria

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DOI: https://dx.doi.org/10.47772/IJRISS.2026.100300035

Received: 03 March 2026; Accepted: 11 March 2026; Published: 24 March 2026

ABSTRACT

This study investigated the effect of environmental mitigation financing on financial efficiency of listed industrial goods firms in Nigeria. Financial efficiency is measured using Economic Value Added, while environmental mitigation financing is proxied by green loan financing, pollution control investment, renewable energy investment, and environmental remediation and clean-up cost. An ex post facto research design was adopted using a balanced panel of 11 industrial goods firms listed on the Nigerian Exchange Group over the period 2015 to 2024. Secondary data were sourced from audited annual reports, sustainability disclosures, and exchange filings, and analysed using panel regression techniques with robust standard errors. The results indicated that green loan financing has a negative but statistically insignificant effect on financial efficiency, suggesting that access to green credit alone does not guarantee value creation. Pollution control investment showed a negative and significant effect on Economic Value Added, reflecting short term cost pressures associated with compliance driven environmental expenditure. In contrast, renewable energy investment exerted a strong positive and significant influence on financial efficiency, while environmental remediation and clean-up cost also recorded a positive and significant effect, indicating that proactive environmental actions enhance operational efficiency and stakeholder confidence. Based on these findings, the study recommended that industrial goods firms prioritise strategic environmental investments, particularly renewable energy initiatives, integrate environmental remediation into core operational planning, and evaluate pollution control expenditures using value-based performance measures. Policymakers and financial institutions were also encouraged to strengthen green finance frameworks by linking funding access to measurable efficiency outcomes.

Keywords: Environmental Remediation and Clean-Up Cost, Financial Efficiency, Green Loan Financing, Pollution Control Investment, Renewable Energy Investment

INTRODUCTION

Financial efficiency enhances profitability, reduces costs, and strengthens firm resilience, and prior studies show that operational efficiency transmits resource efficiency gains into higher profits and lower risk (Fu & Jacobs, 2022). Likewise, evidence links efficiency to higher ROA and market value (Liu et al., 2022; Mahanta et al., 2024). However, this positive role is increasingly constrained in developed economies, where rising funding and compliance costs weaken profitability and credit supply (BIS, 2022). In addition, measurement bias, slower growth, and tighter policy further raise capital costs and reduce allocative efficiency (Wanke, 2023; OECD, 2023).

In contrast, developing countries in Africa face deeper structural efficiency challenges because financial systems are shallow and intermediation is weak. Consequently, limited credit access and low financial inclusion restrict efficiency gains (World Bank, 2024). Moreover, tighter macroeconomic conditions and high policy rates compress margins and raise funding costs (IMF, 2023). In Nigeria, these pressures are compounded by fragile liquidity, high nonperforming loans, and regulatory burdens that continue to undermine bank efficiency (CBN, 2023).

Beyond structural constraints, financial efficiency research itself faces serious measurement problems, particularly in African contexts. Poor data quality and short panels distort efficiency estimates, while deterministic DEA models often overstate performance by ignoring statistical noise (Adebayo & Ilo, 2023; Abiodun, 2022). Furthermore, institutional heterogeneity and regulatory differences weaken cross country comparisons, making advanced bootstrap or stochastic methods necessary for robust inference (Okafor & Yusuf, 2023).

In response, international institutions and governments have introduced reforms aimed at improving efficiency and stability. Prudential regulation and enhanced supervision now emphasize capital and liquidity strength (BIS, 2022), while the IMF supports capacity building, stress testing, and risk based oversight (Adrian, 2023). At the same time, digital finance and payment reforms are promoted to lower intermediation costs, and researchers advocate stronger empirical techniques to correct measurement bias (World Bank, 2023; Arhin et al., 2023).

Against this background, environmental mitigation financing has emerged as a complementary channel for improving financial efficiency. By directing capital toward pollution control, clean technology, and climate risk reduction, it lowers long run costs and operational risk. Evidence from Africa shows that green finance improves productivity and resource efficiency, while environmental investment enhances banking efficiency by reducing risk exposure (Adebayo et al., 2022; Gyamfi et al., 2023). Nigerian studies similarly link green financing to better cost efficiency and profitability through improved capital allocation and innovation (Adeyemi, 2024; Umar et al., 2023).

However, the potential of environmental mitigation financing is constrained by persistent funding gaps. Global assessments show adaptation and mitigation finance remain insufficient, particularly for Africa (UNEP, 2022; UNFCCC, 2023). Concessional finance is inadequate, private flows are limited, and project bankability remains weak, leaving the continent with a large clean energy investment shortfall (IMF, 2023; Climate Policy Initiative, 2024; World Bank, 2022).

Despite growing interest, the literature still leaves important gaps. Most studies focus on banks or macro-outcomes and overlook industrial firms, while evidence on specific mitigation channels such as green loans, pollution control, renewable energy investment, and remediation costs remains limited (Adewuyi & Odusola, 2022; Onyema, 2023). In addition, few studies adopt value-based measures such as economic value added, relying instead on accounting ratios (Ibrahim & Bello, 2023). Consequently, limited firm level evidence exists for listed industrial goods firms in Nigeria, which this study addresses by examining the effect of environmental mitigation financing on financial efficiency proxied by economic value added.

LITERATURE REVIEW

Financial Efficiency

Financial efficiency proxied by Economic Value Added reflects a firm's ability to generate returns above its cost of capital, and it focuses on true economic profit rather than accounting profit. Stewart (2022) defines EVA as net operating profit after tax minus the weighted average cost of capital multiplied by invested capital, while Otero and Durán (2023) emphasize its superiority in capturing value creation and managerial efficiency. However, authors note issues such as sensitivity to capital cost estimation and accounting adjustments, which can bias comparisons across firms and periods (Kyriazis & Anastassis, 2022). Empirical evidence shows that higher EVA improves firm value, investment efficiency, and long-term competitiveness (Ahmed et al., 2023; Adegbite & Nakajima, 2024). Consequently, EVA is measured by adjusting operating profit for taxes and capital charges, making it a robust proxy for financial efficiency in value-based performance analysis (Stewart, 2022; Otero & Durán, 2023).

Environmental mitigation financing

It refers to financial resources allocated to reduce environmental harm and climate risk through prevention, control, and restoration activities. UNEP (2023) defines it as capital directed toward emissions reduction, pollution abatement, and ecosystem protection, while Adebayo et al. (2022) stress its role in improving resource efficiency and long-term productivity. However, studies highlight issues of underfunding, weak targeting, and disclosure gaps, especially in developing economies (UNFCCC, 2023). Empirical evidence links effective mitigation financing to lower operating risk and improved financial efficiency. It is commonly measured using environmental capital expenditure, green finance volumes, or mitigation investment intensity (Adebayo et al., 2022; UNEP, 2023).

Green loan financing

It involves bank lending tied to environmentally beneficial projects under predefined green criteria. Li (2023) defines green loans as credit instruments that incentivize firms to invest in low carbon and pollution reducing activities, while Adeyemi (2024) emphasizes their role in improving capital allocation efficiency in Nigeria. Key issues include greenwashing risk and inconsistent taxonomies across jurisdictions. Evidence shows green loans reduce financing costs and enhance operational efficiency when monitoring is strong (Li, 2023). Measurement is typically based on the value of green loans outstanding or their ratio to total credit (Adeyemi, 2024).

Pollution control investment

It captures firm spending on technologies and processes that reduce emissions, effluents, and waste. Okoro et al. (2024) define it as preventive and end of pipe expenditure aimed at regulatory compliance and environmental protection, although high upfront costs often discourage adoption. Studies find that such investment lowers future remediation costs and operational disruptions, thereby improving efficiency over time (Okoro et al., 2024). Measurement challenges arise from inconsistent disclosure and aggregation with general capital expenditure. Empirical work measures it using pollution control capital or operating expenditure scaled by assets or sales.

Renewable energy investment

It refers to capital committed to energy generation from renewable sources such as solar, wind, and biomass. Ibrahim and Bello (2023) argue that renewable investment enhances energy efficiency and shields firms from fossil fuel price volatility, while others note challenges related to financing costs and infrastructure gaps. Evidence shows that renewable adoption reduces long run energy costs and carbon risk, supporting financial efficiency (Ibrahim & Bello, 2023). Measurement commonly relies on renewable energy capital expenditure, installed capacity, or renewable energy intensity ratios.

Environmental remediation and clean-up cost

It represents expenditure incurred to restore contaminated sites and meet environmental liability obligations. UNEP (2022) defines these costs as corrective rather than preventive, often reflecting past environmental damage, and firms face uncertainty in estimating their magnitude. While such costs may depress short term performance, studies show they reduce legal risk and enhance long term sustainability and efficiency (UNEP, 2022; UNFCCC, 2023). Measurement issues include discretion in provisioning and timing of recognition. Empirical studies proxy remediation using environmental provisions, cleanup expenses, or restoration liabilities relative to firm size.

Theoretical Framework

Stakeholder theory was formally advanced by Freeman in 1984, and it assumes that firms create value by balancing the interests of multiple stakeholder groups rather than shareholders alone. Recent literature extends this view by arguing that environmental investments respond to stakeholder pressure and expectations (Freeman et al., 2023). The theory assumes stakeholders possess power, legitimacy, and urgency that influence managerial decisions, including environmental mitigation financing. In Nigeria, studies show that communities, regulators, and financiers increasingly shape firms' environmental spending choices (Adegbite & Nakajima, 2024; Ogunleye et al., 2023).

Despite its relevance, stakeholder theory faces limitations and critiques. Scholars argue that it lacks clear prioritization among competing stakeholder interests and offers weak predictive power for financial outcomes (Jensen, 2022). Others note measurement challenges in identifying and quantifying stakeholder influence, especially in emerging markets (Adebayo et al., 2023). In Nigeria, weak institutions and enforcement gaps further constrain stakeholder effectiveness, limiting the theory's explanatory strength in some contexts (Umar & Sadiq, 2022).

Nevertheless, the theory offers clear benefits and practical application. It explains why firms invest in green loans, pollution control, renewable energy, and remediation to secure legitimacy, reduce conflict, and sustain long term value (Freeman et al., 2023). Empirical studies link stakeholder oriented environmental strategies to improved efficiency, lower risk, and higher economic value added (Gyamfi et al., 2023; Adeyemi, 2024). For industrial goods firms, stakeholder theory supports the integration of environmental mitigation financing into core financial decision making.

The theoretical justification for adopting stakeholder theory in this study is that environmental mitigation financing represents a strategic response to stakeholder demands that can enhance financial efficiency. By meeting expectations of regulators, financiers, host communities, and customers, firms reduce environmental risk and capital costs, which supports higher economic value added (Adegbite & Nakajima, 2024). Nigerian evidence shows that stakeholder driven environmental investments improve cost efficiency and firm value, validating the theory's relevance (Adeyemi, 2024; Umar et al., 2023). Thus, stakeholder theory provides a robust lens to explain how environmental mitigation financing influences financial efficiency of listed industrial goods firms in Nigeria.

EMPIRICAL REVIEW

Adebayo and Ilo (2023) conducted a panel study of 48 commercial banks in sub Saharan Africa using annual financial reports for 2010–2020, and they sampled banks with continuous disclosures using purposive sampling, and they analysed data with DEA and Malmquist indices. They found green finance improved productivity and dynamic efficiency, and they noted data gaps and limited firm level coverage as limitations, which leaves industrial firms underexplored.

Abiodun (2022) used a stochastic frontier approach on Nigerian bank balance sheet data from 2012–2019, and the population was all deposit money banks while the sample consisted of 22 banks selected by availability of environmental cost data, and inference used SFA with panel corrections. The study reported that deterministic measures overstate efficiency and that accounting for noise lowers estimated efficiency, and it recommended richer environmental expenditure disclosure for better firm level analysis.

Okoro et al. (2024) applied an ex post facto design to 60 manufacturing firms listed in Nigeria for 2014–2020, and they used stratified random sampling with firm annual reports as the data source, and they applied fixed effects regression and robustness checks. They found pollution control investment reduced operating disruptions and improved cost efficiency over time, but disclosure inconsistency and aggregation with general capex limited precise measurement of pollution control outlays.

Ibrahim and Bello (2023) executed a difference in differences panel analysis of 120 listed firms in Nigeria and South Africa for 2010–2021, and they sampled industrial firms adopting on site renewables using matching on firm size, and they used FE regressions on EVA and energy investment variables. They found renewable energy investment significantly raised EVA after three years, and they identified financing cost and grid constraints as moderators that require deeper causal studies.

Adeyemi (2024) performed a mediation analysis on Nigerian deposit money banks using secondary data for 2016–2022, and the sample included 15 banks chosen by green finance reporting, and methods combined SEM and panel OLS. The study reported that green loan financing improved operational efficiency through financial

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue III March 2026

innovation, but small sample size and selection bias in green reporters limited external validity, suggesting a need for broader firm level samples.

Gyamfi et al. (2023) used a cross country panel of 80 banks from 12 Sub Saharan African countries for 2012–2020, and they sampled based on data availability and applied GMM to address endogeneity. They found environmental investment reduced risk exposure and enhanced banking efficiency, but they noted heterogeneity across jurisdictions and weak institutional enforcement as limitations that complicate firm level generalization.

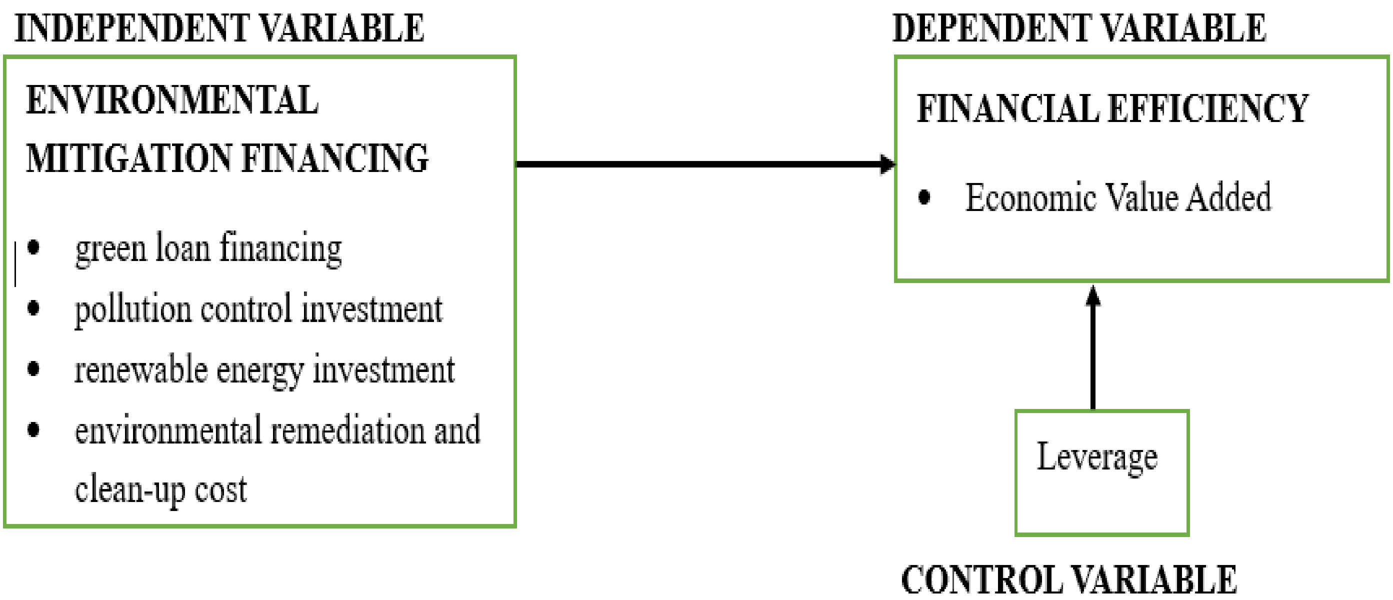
Onyema (2023) implemented an event study and panel regression on 45 Nigerian industrial firms that announced major remediation projects between 2015 and 2021, and the sample was purposive with archival disclosure data, and methods combined abnormal return windows with panel FE models. Results showed short term negative abnormal returns at announcement, and long term improvements in EVA for firms that followed through, and the study flagged the need for more granular remediation cost data and longer post intervention windows.

Ilelaboye et al. (2022) adopted a mixed method design on 30 family-owned manufacturing firms in Nigeria for 2010–2020, and they used survey sampling plus archival accounts to measure restoration costs and performance, and analysis combined panel regression and thematic coding. They found environmental remediation costs depressed short term ROE but improved stakeholder relations and long term sustainability, and they suggested larger samples and comparative industry studies to confirm findings.

Conceptual Framework

Figure 2.1 shows the interaction between the variables under study.

Figure 2.1: Conceptual Framework



Source: Researcher's Design (2026)

METHODOLOGY

This study adopts an ex post facto research design using a balanced panel of listed industrial goods firms in Nigeria. The population comprises all 13 industrial goods firms listed on the Nigerian Exchange Group, and the sample consists of 11 firms selected through purposive sampling based on data availability for the period 2015–2024. Secondary data are sourced from audited annual reports, sustainability reports, and Nigerian Exchange filings. Environmental mitigation financing is proxied by green loan financing, pollution control investment, renewable energy investment, and environmental remediation and clean-up cost, while financial efficiency is measured by economic value added. Data are analysed using panel regression techniques, specifically fixed effects and random effects models, with Hausman tests and robust standard errors applied to ensure reliability.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue III March 2026

Model Specification

The adapted study builds on the green finance and efficiency framework employed by Adeyemi (2024), where financial efficiency is expressed as a function of environmental financing and firm characteristics. In the adapted model, financial efficiency is proxied by cost or profit efficiency, and the model is specified as:

$$FE_{it} = \alpha_0 + \alpha_1 GF_{it} + \alpha_2 ENV_{it} + \alpha_3 LEV_{it} + \mu_{it}$$

Where FE represents financial efficiency of firm i in period t, GF denotes green finance or green credit, ENV captures environmental investment, LEV is leverage, α_0 is the intercept, α_1–α_3 are slope coefficients, and μ is the error term.

Following this framework, this study modifies the model to reflect firm level environmental mitigation financing and a value-based efficiency measure. Accordingly, financial efficiency is proxied by Economic Value Added, and environmental mitigation financing is decomposed into green loan financing, pollution control investment, renewable energy investment, and environmental remediation and clean-up cost, with leverage retained as the control variable. The model is specified as:

$$EVA_{it} = \beta_0 + \beta_1 GLF_{it} + \beta_2 PCI_{it} + \beta_3 REI_{it} + \beta_4 ERC_{it} + \beta_5 LEV_{it} + \varepsilon_{it}$$

Where EVA denotes Economic Value Added of firm i in period t, GLF represents green loan financing, PCI is pollution control investment, REI captures renewable energy investment, ERC denotes environmental remediation and clean-up cost, LEV is leverage, β_0 is the constant, β_1–β_5 are coefficients, and ε is the disturbance term. The a priori expectation is that GLF, PCI, REI, and ERC exert positive effects on EVA, reflecting improved financial efficiency, while leverage is expected to have an ambiguous effect depending on the firm's debt management efficiency.

Measurement of Variables

Table 1: Description and Measurement of Variables

S/N	Variable	Description	Measurement	Sources
1	Financial Efficiency (EVA)- Dependent	Measures the firm's ability to generate economic profit above the cost of capital.	EVA = NOPAT − (WACC × Invested Capital)	Stewart (2022); Ahmed et al. (2023); Otero & Durán (2023)
2	Green Loan Financing (GLF)- Independent	Bank credit obtained for environmentally sustainable projects and activities.	Value of green loans or green loan ratio to total debt	Li (2023); Adeyemi (2024); UNEP (2023)
3	Pollution Control Investment (PCI)- Independent	Capital and operating expenditure aimed at reducing emissions, waste, and effluents.	Pollution control expenditure scaled by total assets	Okoro et al. (2024); Adebayo et al. (2023)
4	Renewable Energy Investment (REI)- Independent	Investment in renewable energy generation and usage such as solar or wind.	Renewable energy expenditure to total capital expenditure	Ibrahim & Bello (2023); World Bank (2023)
5	Environmental Remediation and Clean-up Cost (ERC) - Independent	Costs incurred to restore environmental damage and meet cleanup obligations.	Environmental remediation cost or provision scaled by total assets	UNEP (2022); Onyema (2023); UNFCCC (2023)
6	Leverage (LEV)- Control	Captures the extent of debt financing and financial risk exposure.	Total debt to total assets ratio	Jensen (2022); Gyamfi et al. (2023)

Source: Researcher's Compilation (2026)

RESULTS AND DISCUSSION

Descriptive Statistics

Table 2 presents the descriptive statistics for the variables employed in this study. The sample consists of 11 industrial firms selected through purposive sampling based on data availability over the period 2015–2024, yielding 103 firm-year observations. The statistics reported include the mean, standard deviation, minimum, and maximum values for the dependent, independent, and control variables. The analysis provides an initial understanding of the central tendencies and variability of the study variables before proceeding to inferential estimation.

Table 2 Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
EVA	103	-10.550	16.541	-23.896	20.893
GLF	103	3.496	2.529	0.000	8.693
PCI	103	0.538	1.022	0.000	5.688
REI	103	0.000000813	0.00000218	0.00000000226	0.0000176
ERC	103	0.215	0.563	0.000	4.017
LEV	103	4.890	0.451	2.706	6.025

Source: Researchers' Computation (2026)

The dependent variable, Financial Efficiency (EVA), records a mean value of −10.550, with a standard deviation of 16.541. The negative mean suggests that, on average, the sampled firms did not generate economic profit above their cost of capital during the period under review. The wide dispersion between the minimum (−23.896) and maximum (20.893) values indicates substantial variation in economic performance across firms and years. This variability reflects differences in capital structure, investment strategy, and operating efficiency within the industrial sector.

Green Loan Financing (GLF) reports a mean of 3.496 and a standard deviation of 2.529. The minimum value of zero implies that some firms did not utilize bank borrowing linked to environmentally oriented projects in certain years. The maximum value of 8.693 indicates that, for some firm-year observations, green-related debt financing constituted a notable proportion of total assets. The variation suggests uneven access to or adoption of environmentally linked financing within the sector.

Pollution Control Investment (PCI) shows a mean value of 0.538 and a standard deviation of 1.022. The presence of zero values indicates that some firms reported no identifiable pollution control expenditure in certain years. However, the maximum value of 5.688 suggests that a few firms made relatively substantial investments in environmental management. The spread indicates that environmental expenditure is not uniformly embedded across the sampled firms.

Renewable Energy Investment (REI) records a very small mean of 8.13e−07, with limited dispersion. Both the minimum and maximum values confirm that renewable energy investments, as measured, remain minimal among the sampled firms during the study period. The low magnitude suggests that renewable energy integration is still at an early or negligible stage within the sector.

Environmental Remediation and Clean-up Cost (ERC) shows a mean of 0.215 and a standard deviation of 0.563. While some firms report no remediation costs in certain years, the maximum value of 4.017 indicates that environmental restoration or compliance obligations can be significant when incurred. The moderate variability suggests sporadic but potentially material environmental liabilities.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue III March 2026

Finally, the control variable, Leverage (LEV), records a mean of 4.890 with a relatively small standard deviation of 0.451. The minimum and maximum values, 2.706 and 6.025 respectively, indicate moderate dispersion. The relatively tight spread suggests that the firms exhibit somewhat similar capital structure patterns, though with meaningful differences in debt intensity.

Overall, the descriptive statistics reveal considerable variability in financial efficiency and environmental investment behaviour across the sampled industrial firms, while renewable energy investment remains comparatively low. These patterns provide an empirical foundation for the subsequent regression analysis.

Correlation Matrix and Multicollinearity Test

Table 3 presents the Pearson correlation coefficients among the study variables alongside the Variance Inflation Factor (VIF) values. The inclusion of VIF in the same table provides a consolidated view of both bivariate relationships and multicollinearity diagnostics before proceeding to regression estimation.

Table 3 Correlation Matrix and Variance Inflation Factor (VIF)

Variable	EVA	GLF	PCI	REI	ERC	LEV	VIF
EVA	1.0000						
GLF	0.0087	1.0000					1.56
PCI	0.0028	0.4638	1.0000				3.83
REI	0.1227	-0.3404	-0.1308	1.0000			1.16
ERC	0.0449	0.4754	0.8563	-0.0832	1.0000		4.20
LEV	0.2023	0.0711	-0.2516	-0.1371	-0.3254	1.0000	1.22

Source: Author’s computation (2026)

The correlation coefficients indicate generally weak linear relationships between Financial Efficiency (EVA) and the explanatory variables. None of the independent variables exhibits a strong direct bivariate association with EVA. Leverage shows the highest positive association with EVA (0.2023), though the magnitude remains modest.

Among the explanatory variables, Pollution Control Investment (PCI) and Environmental Remediation Cost (ERC) demonstrate a strong positive correlation (0.8563). This reflects conceptual similarity, as both variables capture dimensions of environmental expenditure. Although the coefficient is high, it does not exceed the critical threshold of 0.90 often associated with severe multicollinearity.

The VIF results reinforce this assessment. All VIF values remain below 5, the commonly accepted conservative benchmark. ERC records the highest VIF value (4.20), followed by PCI (3.83), but both remain within acceptable limits. The mean VIF of 2.39 further confirms that multicollinearity is not statistically problematic in the model.

The combined evidence from the correlation coefficients and VIF statistics suggests that the explanatory variables are sufficiently independent to permit reliable regression estimation.

Diagnostic Tests

This section presents the diagnostic tests conducted to validate the panel regression assumptions. The tests include heteroskedasticity, random effects suitability, model selection, and serial correlation. The results are summarised in Table 4.

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Table 4 Summary of Diagnostic Test Results

Test	Null Hypothesis	Statistic	Probability	Decision	Conclusion
Modified Wald Test	Homoskedasticity ($\sigma^2_i = \sigma^2$)	$\chi^2(11)$ = 179,484.03	0.0000	Reject H_0	Presence of groupwise heteroskedasticity
Breusch–Pagan LM Test	Var(u) = 0 (No panel effect)	chibar²(01) = 22.74	0.0000	Reject H_0	Random effects preferred over pooled OLS
Hausman Test	Difference in FE and RE not systematic	χ^2 = 0.99	0.3205	Do not reject H_0	Random effects model appropriate
Wooldridge Test	No first-order autocorrelation	F(1,10) = 12.120	0.0059	Reject H_0	Presence of serial correlation

Source: Researchers' Computation (2026) using Stata output.

The Modified Wald test reveals significant groupwise heteroskedasticity across firms, as indicated by the highly significant chi-square statistic. This implies that the variance of the error terms differs across the eleven firms in the sample. The homoskedasticity assumption is therefore violated.

The Breusch–Pagan Lagrange Multiplier test rejects the null hypothesis of no panel effects, confirming that firm-specific effects are present. This indicates that pooled OLS is inappropriate, and a panel estimator is required.

The Hausman test suggests that the difference between fixed effects and random effects estimators is not systematic. Since the probability value exceeds 0.05, the random effects estimator is consistent and efficient for this study.

The Wooldridge test detects first-order autocorrelation within panels. This indicates that the error terms are serially correlated over time within individual firms.

Overall, the diagnostics show that the panel structure is valid, the random effects model is appropriate, but the presence of heteroskedasticity and autocorrelation requires the use of robust or cluster-adjusted standard errors in subsequent regression estimation.

REGRESSION RESULTS

This section presents the results of the random effects panel regression estimated with robust standard errors clustered at the firm level. The correction accounts for the heteroskedasticity and serial correlation identified in the previous section. The model examines the effect of Green Loan Financing (GLF), Pollution Control Investment (PCI), Renewable Energy Investment (REI), Environmental Remediation Cost (ERC), and Leverage (LEV) on Financial Efficiency (EVA) for 11 industrial firms over the period 2015–2024.

Table 5 Random Effects Regression Results (Robust Standard Errors Clustered by Firm)

Variable	Coefficient	Robust Std. Error	z-statistic	P-value	95% Confidence Interval
GLF	-0.289	0.738	-0.39	0.695	-1.736 to 1.157
PCI	-4.104	1.059	-3.87	0.000***	-6.180 to -2.028
REI	1,797,102	265,708.7	6.76	0.000***	1,276,323 to 2,317,882
ERC	7.403	3.562	2.08	0.038**	0.423 to 14.384
LEV	11.562	5.941	1.95	0.052*	-0.082 to 23.206
Constant	-66.616	26.906	-2.48	0.013**	-119.351 to -13.882
Model Statistics					
Within R^2 = 0.1317; Between R^2 = 0.0951; Overall R^2 = 0.0687; Wald $\chi^2(5)$ = 283.12; Prob > χ^2 = 0.0000; ρ = 0.3183					

Source: Researchers' Computation (2026).

The Wald chi-square statistic is highly significant, indicating that the explanatory variables jointly influence Financial Efficiency. Approximately 31.8 percent of the variation in EVA is attributable to firm-specific effects, reflecting meaningful unobserved heterogeneity across firms.

Green Loan Financing (GLF) has a negative but statistically insignificant coefficient. This suggests that green-related borrowing does not have a measurable impact on financial efficiency within the sample period.

Pollution Control Investment (PCI) exhibits a negative and statistically significant effect on EVA at the 1 percent level. The coefficient implies that increased pollution control expenditure is associated with reduced short-term economic value added. This finding may reflect compliance costs or high initial environmental investment burdens.

Renewable Energy Investment (REI) shows a positive and highly significant relationship with EVA. Despite its small magnitude in descriptive statistics, its effect is economically large and statistically strong. This indicates that renewable energy initiatives are associated with improved financial efficiency in the sampled firms. The large coefficient reflects scaling, as the variable was measured in very small units.

Environmental Remediation Cost (ERC) is positive and statistically significant at the 5 percent level. This suggests that firms incurring environmental clean-up and compliance costs may experience improved financial efficiency, possibly due to enhanced operational discipline or reputational benefits.

Leverage (LEV) is positive and marginally significant at the 10 percent level. The result implies that debt financing may enhance economic value creation, though the evidence is weaker compared to PCI and REI.

Overall, the results suggest that different dimensions of environmental investment affect financial efficiency differently. Compliance-driven pollution control appears to reduce short-term economic value, while renewable energy investment contributes positively. Remediation expenditure also appears to be associated with improved efficiency. These findings highlight the nuanced relationship between environmental financial decisions and firm performance within the industrial sector.

Test of Hypotheses

This section presents the evaluation of the study hypotheses based on the random effects regression results reported in Table 5. The decisions are made using the 5 percent level of significance.

Hypothesis One

H_{01}: Green Loan Financing (GLF) has no significant effect on Financial Efficiency (EVA).

The regression result shows that GLF has a coefficient of −0.289 with a p-value of 0.695. Since the probability value exceeds 0.05, the null hypothesis cannot be rejected. This indicates that green loan financing does not exert a statistically significant influence on financial efficiency within the sampled industrial firms during the study period. The negative sign suggests a possible short-term financing cost burden, but the effect is not statistically meaningful.

Decision: Fail to reject H_{01}.

Conclusion: Green Loan Financing does not significantly affect Financial Efficiency.

Hypothesis Two

H_{02}: Pollution Control Investment (PCI) has no significant effect on Financial Efficiency (EVA).

PCI records a coefficient of −4.104 with a p-value of 0.000. Since the probability value is less than 0.01, the null hypothesis is rejected. The negative coefficient indicates that increased pollution control investment is associated with a decline in financial efficiency. This suggests that pollution control expenditures may impose short-term cost pressures that reduce economic value added.

Decision: Reject H_{02}.

Conclusion: Pollution Control Investment significantly and negatively affects Financial Efficiency.

Hypothesis Three

H_{03}: Renewable Energy Investment (REI) has no significant effect on Financial Efficiency (EVA).

The coefficient of REI is positive (1,797,102) and highly significant with a p-value of 0.000. The null hypothesis is therefore rejected. Renewable energy investment exhibits a strong positive effect on financial efficiency. Although the magnitude appears large due to scaling, the statistical significance indicates that renewable energy initiatives contribute positively to economic value creation.

Decision: Reject H_{03}.

Conclusion: Renewable Energy Investment significantly and positively affects Financial Efficiency.

Hypothesis Four

H_{04}: Environmental Remediation and Clean-up Cost (ERC) has no significant effect on Financial Efficiency (EVA).

ERC has a coefficient of 7.403 and a p-value of 0.038. Since the probability value is less than 0.05, the null hypothesis is rejected. The positive coefficient suggests that environmental remediation activities are associated with improved financial efficiency. This may reflect reputational benefits, regulatory compliance advantages, or improved operational discipline following environmental interventions.

Decision: Reject H_{04}.

Conclusion: Environmental Remediation Cost significantly and positively affects Financial Efficiency.

The hypothesis testing reveals that Renewable Energy Investment and Environmental Remediation Cost significantly enhance financial efficiency, while Pollution Control Investment reduces it in the short term. Green Loan Financing does not demonstrate a statistically significant effect.

DISCUSSION OF FINDINGS

This study examined the effect of green loan financing, pollution control investment, renewable energy investment, and environmental remediation cost on financial efficiency measured using Economic Value Added. The discussion integrates the empirical results with existing theoretical and empirical literature.

The regression results show that green loan financing does not exert a statistically significant influence on financial efficiency. This finding contrasts with the argument that green finance improves firm performance by enhancing resource allocation and environmental outcomes, as suggested by Adebayo, Kirikkaleli, and Adeshola (2022) and Li (2023), who report that green credit improves green investment efficiency. Similarly, Adeyemi (2024) documents a positive association between green finance and financial efficiency among Nigerian deposit money banks. However, the insignificant result in this study suggests that green borrowing alone may not automatically translate into value creation. It may be that such financing increases short-term financial obligations without immediate performance gains. This aligns with the broader evidence that the effectiveness of green finance depends on institutional quality and operational efficiency (Gyamfi, Bein, & Bekun, 2023; Nwanyanwu, 2023). The result therefore suggests that financing mechanisms are not inherently value-enhancing unless efficiently deployed.

Pollution control investment exhibits a negative and statistically significant effect on financial efficiency. This suggests that increased pollution control expenditure reduces short-term economic value added. The finding is consistent with Adewuyi and Odusola (2022) and Onyema (2023), who document that environmental expenditures can impose cost burdens on firms, particularly where compliance spending is reactive rather than strategic. Okoro, Chukwuemeka, and Eze (2024) also report that pollution control investment may initially reduce firm efficiency in Nigeria's manufacturing sector. From a value-based perspective, EVA captures residual profit after the cost of capital. Consequently, heavy compliance costs without proportional revenue gains may suppress economic value. This finding reflects the tension identified in stakeholder theory, where meeting environmental obligations may conflict with short-term shareholder value (Freeman, Phillips, & Sisodia, 2023). The implication is that pollution control investment must be efficiency-driven rather than purely regulatory compliance expenditure.

In contrast, renewable energy investment demonstrates a strong positive and statistically significant effect on financial efficiency. This supports the argument that strategic environmental investments can enhance firm value. Ibrahim and Bello (2023) find that renewable energy investments improve financial performance of listed firms in Nigeria. Similarly, Liu, Wu, and Zhou (2022) show that ESG integration positively affects corporate financial performance when embedded within operational efficiency structures. Fu and Jacobs (2022) further argue that environmental efficiency improves financial outcomes when linked to productivity improvements. From a value-based performance standpoint, Adegbite and Nakajima (2024) emphasize that value creation in emerging markets depends on strategic capital allocation. Renewable energy investment appears to function not as compliance expenditure, but as a strategic efficiency-enhancing mechanism. It may reduce long-term operating costs, energy volatility, and environmental risk exposure. This aligns with the resource efficiency view embedded in green finance literature.

Environmental remediation and clean-up cost also shows a positive and statistically significant relationship with financial efficiency. At first glance, remediation costs may appear to reduce profitability. However, this result suggests that proactive environmental restoration may improve corporate reputation, stakeholder trust, and long-term operational stability. Umar and Abdulwahab and Sadiq (2023) find that environmental investment improves bank performance in Nigeria. Ogunleye, Sadiq, and Umar (2023) also emphasize that environmental governance enhances corporate performance through stakeholder confidence. Under stakeholder theory, environmental accountability can reduce reputational risk and regulatory exposure, thereby improving sustainable value creation (Freeman et al., 2023). The result suggests that remediation, unlike routine pollution control, may function as a corrective efficiency mechanism that strengthens long-term economic value.

Overall, the findings reveal a differentiated impact of environmental finance dimensions on firm performance. Compliance-oriented pollution control appears to reduce short-term economic value, whereas strategic renewable energy investment and remediation expenditures enhance financial efficiency. This distinction aligns with the evolving green finance narrative in Africa, where climate finance gaps remain substantial (Climate Policy Initiative, 2024; UNFCCC, 2023). The results suggest that not all environmental expenditures are equal in their economic implications. Strategic sustainability investment enhances value creation, while reactive regulatory spending may impose short-term cost burdens.

In value-based performance terms, the use of Economic Value Added strengthens the interpretation. EVA captures economic profit beyond the cost of capital (Stewart, 2022; Kyriazis & Anastassis, 2022; Otero & Durán, 2023; Ahmed, Hussain, & Raza, 2023). Therefore, the positive impact of renewable and remediation investments indicates that these expenditures generate returns exceeding their capital cost, whereas pollution control investments may not yet achieve such returns within the study period.

CONCLUSION AND RECOMMENDATION

Conclusion

This study examined the effect of environmental mitigation financing on the financial efficiency of listed industrial goods firms in Nigeria over the period 2015–2024. Financial efficiency was measured using Economic Value Added, while environmental mitigation financing was proxied by green loan financing, pollution control investment, renewable energy investment, and environmental remediation and clean-up costs. Leverage was included strictly as a control variable to account for capital structure effects.

The findings show that not all environmental financing mechanisms produce the same economic outcomes. Pollution control investment exerts a negative and significant effect on financial efficiency, suggesting that compliance-driven environmental expenditures impose short-term cost pressures that reduce economic value added. In contrast, renewable energy investment demonstrates a strong positive and significant impact on financial efficiency, indicating that strategic sustainability investment enhances long-term value creation. Environmental remediation and clean-up cost also exhibits a positive effect, suggesting that corrective environmental actions may strengthen operational discipline, regulatory standing, and stakeholder confidence. Green loan financing, however, does not show a statistically significant influence on financial efficiency, implying that access to green financing alone does not guarantee value creation unless funds are efficiently deployed.

Overall, the evidence indicates that environmental mitigation financing affects firms differently depending on whether it is reactive and compliance-oriented or proactive and strategically embedded. Industrial goods firms that integrate renewable energy and structured remediation efforts into their operational model appear better positioned to generate economic value beyond the cost of capital. The results reinforce the view that environmental responsibility and financial efficiency are not inherently contradictory, but the pathway through which environmental financing is structured and implemented determines its economic impact.

Recommendation

First, listed industrial goods firms should prioritize strategic environmental investments, particularly renewable energy integration. Renewable energy initiatives appear to enhance financial efficiency and contribute to sustainable value creation. Firms should embed energy transition strategies into long-term capital budgeting rather than treating them as peripheral environmental commitments.

Second, environmental remediation programs should be implemented proactively rather than reactively. Structured environmental restoration can strengthen regulatory compliance, reduce litigation risk, and enhance corporate reputation. Firms should adopt integrated environmental management systems that align remediation spending with operational efficiency goals.

Third, pollution control investments should be optimized for efficiency. Management should ensure that pollution control expenditures are technology-driven and productivity-enhancing rather than merely compliance-based. Investment appraisal techniques such as EVA-based project evaluation should be applied to environmental capital expenditure to ensure that such spending generates returns above the cost of capital.

Fourth, policymakers and regulators should design green finance frameworks that link financing access to measurable efficiency outcomes. Since green loan financing alone does not guarantee improved financial efficiency, financial institutions should incorporate monitoring mechanisms to ensure that borrowed funds are deployed toward productivity-enhancing environmental projects.

Finally, capital structure decisions should continue to be managed prudently, as leverage remains an important firm characteristic influencing financial efficiency. However, leverage should complement, not substitute for, sustainability-driven capital allocation.

Limitation of the Study

This study is subject to several limitations that should be considered when interpreting the findings. First, the analysis is restricted to listed industrial goods firms in Nigeria, which limits the generalisability of the results to other sectors and unlisted firms. Second, the study relies solely on secondary data obtained from annual reports and sustainability disclosures, and this may be affected by disclosure inconsistency, measurement bias, and possible underreporting of environmental expenditures. Third, environmental mitigation financing variables, particularly renewable energy investment and remediation cost, exhibit scaling and disclosure challenges that may influence coefficient magnitude and interpretation. Fourth, the use of Economic Value Added depends on accurate estimation of the cost of capital, and variations in WACC assumptions across firms may affect comparability. Finally, the study adopts a linear panel regression framework, which may not fully capture dynamic or nonlinear effects of environmental investments on financial efficiency over time.

Suggestions for Further Studies

Future studies should extend the scope beyond listed industrial goods firms to include other sectors such as manufacturing, energy, and services, as well as unlisted firms, to enhance external validity. Further research may adopt longer time horizons or dynamic panel techniques to capture lagged and cumulative effects of environmental mitigation financing on financial efficiency. In addition, alternative value based and market based performance measures, such as market value added or Tobin’s Q, could be employed alongside Economic Value Added to provide comparative insights. Future studies may also incorporate moderating or mediating variables such as corporate governance quality, firm size, or institutional effectiveness to deepen understanding of the transmission mechanism. Finally, qualitative or mixed method approaches could complement quantitative analysis by providing deeper insight into managerial decision making and strategic motivations behind environmental investment choices.

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