

ENVIRONMENTAL COSTS AND FINANCIAL PERFORMANCE OF SELECTED LISTED FIRMS IN NIGERIA: THE SHORT- AND LONG-RUN EFFECTS

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ABSTRACT.

Background: Environmental expenditures generate divergent financial outcomes in Nigerian listed firms based on strategic orientation. **Aims:** This study examines how internal and external environmental costs differentially affect operating cash flow margin and market-to-book value ratio. **Methods:** The Pooled Mean Group (PMG) ARDL/ECM estimator was applied to examine the short- and long-run effects. **Sample:** The study used 150 firm-year observations from ten Nigerian manufacturing firms (2010-2024). **Results:** The PMG long-run estimates show a clear asymmetry: internal environmental costs are positively and significantly associated with operating cash flow margin ($\beta = 4.85, p < 0.001$) and market-to-book value ratio ($\beta = 16.48, p < 0.001$), while external environmental costs show significant negative associations with both ($\beta = -6.31$ and -20.34 , respectively, $p < 0.001$). Short-run effects show immediate market reactions to environmental incidents, whereas preventive investments yield gradual returns. Error correction terms (-0.39 to -0.42) indicate 39-42% annual adjustment toward equilibrium, highlighting that avoiding failures delivers greater financial value than incremental prevention. **Conclusions:** Findings establish that the cost allocation strategy, not aggregate spending, determines performance, positioning proactive environmental management as value creation rather than regulatory compliance. **Implications:** The study provides empirical grounding for Nigeria's sustainability disclosure framework by demonstrating that capital markets reward prevention and penalize remediation.

Keywords: Environmental expenditures, Internal costs, External costs, Financial performance

JEL Classification: D02, O17, P31

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Introduction

Contemporary assessments of organizational success have evolved beyond traditional financial metrics such as revenue and profitability. Today's organizations operate within a broader framework that encompasses societal expectations, regulatory obligations and ecological boundaries. In Nigeria, rapid industrialization, expanding urban centers and escalating energy consumption have intensified stress on natural resources, particularly air, soil and aquatic ecosystems, bringing environmental degradation to the forefront of public discourse. Among Nigerian enterprises, publicly traded companies occupy a pivotal position in addressing these challenges, as they face heightened accountability from shareholders, regulators and civil society (Oshiole, Elamah & Ndubuisi, 2020). Their environmental stewardship becomes evident through sustainability disclosures and corporate reporting practices, which significantly influence stakeholder trust. The resources these organizations allocate toward pollution mitigation, regulatory adherence and ecological risk management extend beyond conventional accounting classifications. Rather, such expenditures represent deliberate strategic decisions that signal corporate commitment to sustainability, regulatory engagement and the preservation of long-term organizational value collectively conceptualized as environmental cost (Akinleye, 2022).

Organizations incur environmental costs when they allocate financial resources toward activities designed to minimize ecological damage, comply with environmental regulations, or restore affected ecosystems (Al-Waeli, Ismail & Khalid, 2020). These expenditures extend beyond direct outlays for waste management to encompass indirect investments such as process modifications, sustainable technology adoption, employee environmental training and product redesign for regulatory compliance (Nwakaego, Ihendinihu & Belonwu, 2020; Idowu & Agboola, 2021). These costs fall into two categories. Internal costs are strategic, planned investments aimed at avoiding environmental harm. Examples include emission control systems, water recycling infrastructure and sustainability training (Ekpoese & Enidiok, 2021; Akinleye, 2022). External costs, however, arise after environmental damage occurs or regulatory breaches are detected, such as fines, mandated cleanups, or community compensation (Kurawa & Shuaibu, 2022). Unlike preventive spending, reactive costs are typically unplanned, financially disruptive and reputationally damaging (Osigbemhe, Inyama & Uwuigbe, 2022). Distinguishing between these types is essential for accurately assessing their impact on corporate performance.

Performance measures how effectively a firm transforms resources into economic returns, reflecting both operational execution and strategic direction (Akinleye, 2022; Oyedokun & Erinoso, 2022). This study employs two complementary metrics. Operating cash flow margin cash from operations divided by revenue, reveals whether environmental spending supports or weakens a firm's liquidity, moving beyond accrual-based profits to actual cash generation (Ayu, Lindrianasari, Gamayuni & Urbański, 2023). The market-to-book ratio compares market capitalization to accounting net worth, capturing how investors price environmental risk: proactive stewardship may yield valuation premiums, while recurring ecological failures often trigger market skepticism and discounted valuations (Lawrence & Elaigwu, 2023). Together, these indicators assess both operational resilience and market perception in relation to environmental costs. While environmental expenditures have received scholarly attention in Nigeria, most studies aggregate these outlays into a single metric, masking critical distinctions in their financial implications. Internally driven environmental costs, strategic investments in prevention and efficiency often yield operational savings and risk mitigation over time (Akinleye, 2022). Externally imposed costs, however, typically arise from regulatory breaches or ecological incidents, reflecting reactive expenditures that drain resources without generating strategic value (Abdullahi & Muhammad, 2023). Nigeria's multi-agency regulatory framework subjects firms across sectors, manufacturing, oil and gas and utilities to varied environmental obligations, shaping divergent spending patterns. Proactive investment may avert penalties and bolster financial resilience, whereas delayed action often triggers fines, remediation expenses and reputational damage that weaken cash flows and investor sentiment (Enekwe, Ugwudioha & Uyagu, 2023). Yet few studies disaggregate internal from external environmental costs when evaluating financial outcomes, obscuring how distinct environmental strategies influence performance. This research addresses that gap by isolating these cost categories and examining their differential effects on operating cash flow margin and market-to-book value among Nigerian listed firms.

Nigerian publicly listed firms face mounting pressure to align profitability with ecological stewardship. Yet converting environmental expenditures into tangible financial gains remains elusive (Abbas, Zuriadah & Azam, 2020). A critical oversight in current practice and research is the conflation of internally driven costs (e.g., pollution prevention, green technology adoption, sustainability training) with externally imposed costs (e.g., regulatory fines, spill remediation, legal settlements). These

categories carry divergent financial implications: proactive investments may yield efficiency gains over time, while reactive outlays typically drain resources without strategic benefit (Abdullahi & Muhammad, 2023). Several constraints undermine effectiveness. Substantial upfront capital requirements can strain liquidity, delaying returns on preventive spending (Ade, 2024). Fragmented regulatory enforcement creates uncertainty, complicating cost-benefit projections (Adebisi & Rangu, 2024). Technical capacity gaps lead to inefficient resource allocation, while reactive expenditure patterns triggered by penalties or incidents often erode profitability and investor trust (Agbo & Gina, 2021; Adegbe, Akintoye & Taiwo, 2020). Furthermore, isolating the operational versus market-driven impacts of environmental spending remains methodologically challenging (Agbo & Gina, 2021). Although global scholarship has examined environmental-financial linkages across diverse economies, including Nigeria, critical gaps persist. Most studies treat environmental cost as a monolithic variable, obscuring how internal and external components differentially influence performance. Many rely on aggregate metrics like net profit, neglecting nuanced indicators. Crucially, few investigations distinguish short-run operational effects from long-run market valuation impacts. This study addresses these limitations by disaggregating environmental costs and analysing their distinct short- and long-run effects on cash-flow-based and market-based performance metrics among Nigerian listed firms.

Theoretical background

Existing research on environmental costs and financial performance reveals divergent findings shaped by contextual factors, measurement approaches and cost categorization. Nigerian studies dominate this literature, yet critical gaps persist regarding the differential impacts of internal versus external environmental expenditures. Several investigations report positive associations. Oshiole, Elamah and Ndubuisi (2020) found that environmental cost disclosures significantly enhanced net profit among Nigerian multinationals (2010–2019). Similarly, Arumona, Lambe and Ogunmakinde (2020) documented that comprehensive environmental disclosures improved profitability metrics across 12 Nigerian oil and gas companies. Nwakaego, Ihendinihu and Belonwu (2020) linked environmental investments to stronger earnings in the sector, while Major and Nwdighoha (2024) observed that waste management, health/safety and community development costs all positively influenced return on capital in Nigeria's food industry. Conversely, some studies report neutral or negative effects. Akinleye (2022) found that internal environmental costs exerted a significant negative impact on outcomes among Nigerian listed firms, suggesting that without strategic alignment, preventive spending may initially constrain profitability. Riyadh et al. (2020) similarly observed that green accounting costs reduced return on capital employed among global multinationals, highlighting potential short-term trade-offs. Osigbemhe, Inyama and Uwuigbe (2022) detected no significant relationship between training, medical, and donation costs and brewery firms' performance, possibly reflecting inadequate investment scale or misallocation. A critical limitation cutting across this body of work is the predominant aggregation of environmental costs into undifferentiated totals. While Idowu and Agboola (2021) and Ekpoese and Enidiok (2021) examined specific cost components (e.g., remediation, health costs), few studies systematically distinguish preventive internal costs from reactive external costs and trace their distinct financial pathways. Kurawa and Shuaibu (2022) and Abdullahi and Muhammad (2023) made partial progress by analysing disclosure components and separating accounting-based from market-based outcomes yet neither explicitly modelled short- versus long-run dynamics. Furthermore, most research relies on conventional profitability metrics (ROA, ROE, net profit margin), neglecting liquidity-focused indicators like OCFM that better capture the immediate operational impact of environmental spending. Market-based measures such as the MBVR remain underutilized despite their capacity to reflect investor perceptions of environmental risk and stewardship. International evidence offers mixed signals.

Al-Waeli, Ismail and Khalid (2020) found that conventional environmental costs weakly improved Iraqi firms' performance while hidden costs impaired it, underscoring measurement complexity. Ayu et al. (2023) demonstrated that transparency in environmental and social cost disclosure enhanced performance among energy firms, mediated by reduced earnings management. Collectively, these studies confirm that environmental expenditures influence financial outcomes, but the direction, magnitude and temporal pattern of these effects depend critically on: (1) whether costs are proactive or reactive; (2) the performance metric employed; and (3) the time horizon considered. The absence of research explicitly modelling internal versus external costs and their differential short- and long-run effects on both cash-flow-based and market-based indicators represents a significant empirical gap, particularly within Nigeria's evolving regulatory landscape. This study addresses that gap

by disaggregating environmental cost categories and tracing their distinct pathways to operating cash flow margin and market-to-book value among Nigerian listed firms. Specifically, it seeks to answer:

1. What is the short-run impact of internal environmental costs on financial outcomes?
2. What is the long-run effect of internal environmental costs on financial outcomes?
3. How do external environmental costs affect financial outcomes in the short run?
4. What is the long-run influence of external environmental costs on financial outcomes?

Stakeholder Theory

Originating from Freeman's (1984) seminal work, Stakeholder Theory reconceptualizes the firm as a nexus of relationships extending beyond shareholders to include regulators, communities, employees, customers, and the natural environment itself. Long-term viability, the theory posits, hinges on balancing these diverse interests rather than pursuing shareholder primacy alone. Environmental expenditures emerge as strategic responses to stakeholder pressures: internal costs (e.g., clean technology adoption, sustainability training) reflect proactive alignment with expectations, while external costs (fines, remediation) signal failures in stakeholder engagement that trigger sanctions or reputational harm (Clarkson, 1995; Donaldson & Preston, 1995). In Nigeria's regulatory landscape where agencies like NESREA enforce environmental standards and communities increasingly challenge industrial impacts, firms that anticipate stakeholder concerns often secure stronger market confidence and liquidity (Jones, Harrison & Felps, 2018). Empirical work by Al-Waeli, Ismail and Khalid (2020) further links stakeholder-responsive environmental practices to improved cash flows and valuation metrics. Critiques acknowledge the theory's ambiguity in prioritizing competing stakeholder claims (Mitchell, Agle & Wood, 1997) and its occasional tension with narrow financial objectives (Jensen, 2002). Nevertheless, it provides a vital foundation for interpreting environmental costs not as burdens but as strategic investments in legitimacy and resilience, directly informing this study's focus on how proactive versus reactive spending shapes operating cash flow margin and market-to-book ratios.

Pollution Prevention Cost Theory

Pollution Prevention Cost Theory distinguishes environmental expenditures along a temporal and strategic axis: preventive (internal) versus corrective (external). Rooted in environmental accounting literature (Schaltegger & Burritt, 2017), the theory asserts that investments made before harm occurs, such as energy-efficient systems, closed-loop water recycling, or process redesign, often yield dual benefits: reduced ecological impact and enhanced operational efficiency (Bennett et al., 2002). Conversely, reactive outlays triggered after incidents, regulatory penalties, spill cleanups and litigation typically drain resources without generating strategic value (Al-Waeli, Ismail & Khalid, 2020). This dichotomy proves especially relevant in Nigeria's multi-sector context, where manufacturing, oil and gas, and utility firms face escalating environmental scrutiny. Preventive spending may stabilize cash flows through efficiency gains, while reactive costs often disrupt liquidity and trigger market skepticism (Oshiole, Elamah & Ndubuisi, 2020). Measurement challenges persist, as preventive benefits frequently materialize indirectly or over extended horizons (Horngren et al., 2018), and firms may simultaneously deploy both strategies under regulatory duress. Yet the theory's core insight remains robust: timing and intent fundamentally shape environmental costs' financial consequences. It thus justifies this study's disaggregation of internal and external costs and its examination of their distinct short- and long-run effects on liquidity (via OCFM) and market perception (via MBVR). Together, these theories frame environmental expenditures as strategic choices embedded in stakeholder dynamics and temporal decision-making, providing the conceptual architecture to analyse how Nigerian firms' environmental cost management translates into measurable financial performance.

Methodology

Research Design and Sampling Procedure

This study adopts an ex-post facto design, analysing pre-existing secondary data that cannot be experimentally manipulated. The approach is appropriate for examining historical relationships between environmental expenditures and financial outcomes using audited annual reports and sustainability disclosures of Nigerian publicly listed firms. In this study, a purposive sampling method was used to select ten companies from the seventy-one listed manufacturing firms on the Nigerian

Exchange Group (NGX) as at 31st December, 2022. This purposive approach was selected as it would produce data that are comparable, complete, and available for estimation through panel analysis. To be included, companies met four specific criteria. First, we restricted our sample to firms that are continuously listed on the NGX over the 2010-2024 period, thereby ensuring a balanced panel and eliminating survivorship bias. Second, our firms also had to have easily accessible, complete, audited annual reports for all the years under consideration. Third, firms should clearly report on environmental-related expenses in annual reports or sustainability reports over the time-frame, since the measurement for this variable was based on these reports. Fourth, companies that failed on any one or combination of these characteristics, or those which experienced missing observations, irregularities in reporting, mergers, acquisitions resulting in changes in reporting characteristics, or lengthy trade suspensions, were omitted from the final sample. Our strategy reduces the study population from seventy-one companies to ten companies for panel analysis, providing accurate, robust estimates based on consistent and available financial information.

Econometric Model and A Priori Expectations

This study adapts and extends the econometric framework employed by Akinleye (2022) to examine environmental cost-performance linkages among Nigerian listed firms. While the original model related outcomes to internal environmental costs alongside control variables (firm size and leverage), the present study refines this specification to align with its core objectives. Specifically, the model is reconceptualized along two dimensions. First, environmental cost is disaggregated into its internal and external components to capture their distinct financial implications. Second, financial performance is proxied by two complementary indicators: Operating Cash Flow Margin (OCFM) to reflect operational liquidity and Market-to-Book Value Ratio (MBVR) to capture market-based valuation. The functional relationships are expressed as:

$$OCFM = f(INEN, EXEN, FSIZ, LEVE) \dots \dots \dots (1)$$

$$MBVR = f(INEN, EXEN, FSIZ, LEVE) \dots \dots \dots (2)$$

Where:

OCFM = Operating Cash Flow Margin

MBVR = Market-to-Book Value Ratio

INEN = Internal Environmental Cost (preventive expenditures)

EXEN = External Environmental Cost (reactive expenditures)

FSIZ= Firm Size

LEVE= Leverage

The corresponding econometric specifications for panel data analysis are:

$$OCFM_{it} = \beta_0 + \beta_1 INEN_{it} + \beta_2 EXEN_{it} + \beta_3 FSIZ + \beta_4 LEVE_{it} + U_t \dots \dots \dots (3)$$

$$MBVR_{it} = \beta_0 + \beta_1 INEN_{it} + \beta_2 EXEN_{it} + \beta_3 FSIZ + \beta_4 LEVE_{it} + U_t \dots \dots \dots (4)$$

Based on theoretical expectations from Stakeholder Theory and Pollution Prevention Cost Theory, the study hypothesizes that:

$\frac{\partial OCFM}{\partial INEN} > 0$; This implies that internal environmental cost is expected to have a positive effect on operating cash flow margin.

$\frac{\partial OCFM}{\partial EXEN} > 0$; This implies that external environmental cost is expected to have a negative effect on operating cash flow margin.

$\frac{\partial OCFM}{\partial FSIZ} > 0$; This implies that firm size is expected to positively influence the operating cash flow margin.

$\frac{\partial OCFM}{\partial LEVE} > 0$; This implies that leverage is expected to have a negative effect on the operating cash flow margin.

$\frac{\partial MBVR}{\partial INEN} > 0$; This implies that internal environmental cost is expected to positively influence the market-to-book value ratio.

$\frac{\partial MBVR}{\partial EXEN} > 0$; This implies that external environmental cost is expected to have a negative effect on the market-to-book value ratio.

$\frac{\partial MBVR}{\partial FSIZ} > 0$; This implies that firm size is expected to positively influence the market-to-book value ratio.

$\frac{\partial MBVR}{\partial LEVE} > 0$; This implies that leverage is expected to have a negative effect on the market-to-book value ratio.

Analytical Framework and Data Sources

To model how environmental costs simultaneously shape immediate profitability and long-term value creation, this study applies a panel ARDL framework within the Pooled Mean Group (PMG) estimator, which permits long-run coefficient homogeneity across firms while allowing short-run dynamics and error variances to differ. It permits long-run coefficient homogeneity across firms while allowing short-run dynamics to vary, tolerating mixed integration orders and eliminating spurious regression risk. Estimation proceeds in four steps. First, the Levin-Lin-Chu (LLC) and Im-Pesaran-Shin (IPS) tests establish each series' order of integration. Second, the Pedroni panel cointegration test confirms long-run equilibrium relationships across within- and between-dimension statistics. Third, PMG extracts long-run coefficients, with a Hausman test confirming its preference over the Mean Group estimator. Fourth, a panel error correction model captures short-run dynamics, with the error correction term expected to be negative and significant. Model validity is assessed via coefficient sign coherence, R^2 , and the Pesaran CD, Wooldridge, Modified Wald, and CIPS diagnostics. Data are secondary, drawn from audited annual reports of ten purposively selected NGX-listed firms over a 15-year panel.

Measurement and Operationalisation of Variables

Environmental cost data were extracted from audited annual reports (2010–2024) through content analysis of financial statement notes, directors' reports, and CSR/sustainability disclosures, and standardised by total revenue. Internal environmental cost (INEN) captures prevention-oriented spending, pollution control, emission reduction, environmental training, recycling, and energy efficiency, while external environmental cost (EXEN) captures damage-related spending, fines, remediation, compensation, and litigation or settlement costs; both are measured as the respective cost divided by total revenue. Firm size (FSIZ) is the natural log of total assets, leverage (LEVE) is total debt over total assets, operating cash flow margin (OCFM) is cash flow from operations over total revenue, and the market-to-book value ratio (MBVR) is market capitalisation over book value of equity. Where firms reported environmental costs as a single aggregated figure, narrative disclosures were used to disaggregate items by economic purpose, and all classifications were independently verified by a second coder, with discrepancies resolved through re-examination of the source disclosures.

Results

Table 1: Summary Statistics

	OCFM	MBVR	INEN	EXEN	FSIZ	LEVE
Mean	0.133640	2.577733	0.010616	0.005326	10.454802	0.414309
Median	0.147500	2.350000	0.009400	0.004700	10.451461	0.406474
Maximum	0.295000	5.450000	0.016000	0.008000	12.489303	0.726654
Minimum	-0.250000	0.620000	0.007000	0.003500	7.813565	0.193543
Std. Dev.	0.078614	1.048850	0.002423	0.001205	0.873391	0.105113
Skewness	-1.017053	0.880843	0.896468	0.892728	-0.112745	0.191698
Kurtosis	7.499395	3.609071	2.340768	2.341029	2.975554	2.608881
JB Stat	152.3884	21.71572	22.80752	22.63812	0.321523	1.874812
JB p-value	0.0000	0.0000	0.0000	0.0000	0.8515	0.3916
Obs	150	150	150	150	150	150

Source: Author's computation (Stata 17), 2026.

Across 150 firm-year observations spanning ten NGX-listed manufacturing firms over 2010–2024, the average Operating Cash Flow Margin (OCFM) of 0.1336 indicates that sampled firms retain approximately 13 kobo in operating cash per naira of revenue. This average, however, conceals considerable within-panel variation: the negative skewness of -1.017, excess kurtosis of 7.499, and minimum value of -0.250 collectively point to episodes of acute cash flow deterioration among certain firms in specific years, a pattern not uncommon within Nigeria's volatile macroeconomic environment. The Market-to-Book Value Ratio (MBVR) averages 2.578, suggesting that the market generally prices sampled manufacturers above their accounting book values; the distribution nonetheless stretches from

0.620 to 5.450, exposing sharply divergent market assessments that may reflect cross-firm differences in growth prospects, environmental risk exposure, or governance credibility.

An asymmetry characterises environmental cost allocation: sampled firms direct roughly twice as much spending toward prevention as toward remediation, with internal costs (INEN) averaging 1.06% of revenue against 0.53% for external costs (EXEN). Both carry similar positive skewness of approximately 0.89, indicating that most firms maintain conservative environmental budgets while a minority channels substantially higher proportions into proactive ecological stewardship. Firm size (FSIZ), measured as the natural log of total assets (in millions of naira), averages 10.455, equivalent to an asset base of approximately ₦34.7 billion, and is approximately normally distributed ($JB = 0.3215$, $p = 0.8515$). Leverage (LEVE) averages 0.414 with a narrow standard deviation of 0.105, suggesting capital structure convergence among sampled firms, and is similarly normal ($JB = 1.8748$, $p = 0.3916$). The four primary variables, OCFM, MBVR, INEN and EXEN, all decisively reject normality at conventional significance levels, justifying the adoption of robust panel econometric techniques in the analysis that follows.

Table 2: Bivariate Correlation Matrix and Variance Inflation Factors

	Outcomes		Predictors		Controls	
	OCFM	MBVR	INEN	EXEN	FSIZ	LEVE
OCFM	1	0.4506**	0.0970	0.0981	0.1002	-0.1198
MBVR	0.4506**	1	0.3152**	0.3166**	0.3351**	-0.1112
INEN	0.0970	0.3152**	1	0.2998**	0.2271**	0.1950*
EXEN	0.0981	0.3166**	0.2998**	1	0.1030	0.1956*
FSIZ	0.1002	0.3351**	0.2271**	0.1030	1	0.3484**
LEVE	-0.1198	-0.1112	0.1950*	0.1956*	0.3484**	1
Variance Inflation Factors (VIF)			1.1443	1.1119	1.1734	1.1812
Note: ** $p < 0.01$, * $p < 0.05$, (two-tailed, $n = 150$). Correlation coefficients measure the degree of association between variables. The VIF values are all below the threshold of 10, indicating the absence of serious multicollinearity among the explanatory variables.						

Source: Author's computation (Stata 17), 2026.

A preliminary examination of bivariate associations reveals patterns that are both theoretically coherent and empirically informative. The moderate positive correlation between OCFM and MBVR (0.4506) confirms that firms generating stronger operational cash flows tend to attract higher market valuations, an intuitive alignment between accounting and market-based performance that validates the use of both indicators as complementary rather than redundant measures of financial performance. MBVR records positive associations with INEN (0.3152) and EXEN (0.3166) of nearly identical magnitude, a symmetry that likely reflects a size confound: larger firms simultaneously command higher market valuations and incur greater absolute environmental expenditures across both categories, an interpretation supported by the positive correlations between FSIZ and both INEN (0.2271) and EXEN (0.1030). Notably, OCFM's bivariate associations with INEN (0.0970) and EXEN (0.0981) are negligible, suggesting that cash flow effects of environmental cost composition are not discernible at the bivariate level and emerge only within a multivariate framework that controls for firm-level heterogeneity, precisely the motivation for the regression analysis that follows.

Leverage (LEVE) records negative correlations with both OCFM (-0.1198) and MBVR (-0.1112), consistent with the financial theory that higher debt obligations compress operational cash flows and introduce investor risk discounting that weighs on market multiples. The positive FSIZ-LEVE correlation (0.3484) reflects the well-documented tendency of larger firms to carry greater absolute debt, a structural feature of capital markets in bank-dominated economies such as Nigeria. Critically, no pairwise correlation among the four explanatory variables exceeds 0.35, remaining well below the conventional multicollinearity threshold of 0.80. This is further confirmed by Variance Inflation Factor values of 1.1443 (INEN), 1.1119 (EXEN), 1.1734 (FSIZ) and 1.1812 (LEVE), all comfortably below the critical threshold of 10, establishing that multicollinearity poses no threat to the integrity of subsequent coefficient estimates.

Table 3: Panel Unit Root Test Results

Var	At Level				At First Difference				O(1)
	LLC		IPS		LLC		IPS		
	T-stat	p(v)	T-stat	p(v)	T-stat	p(v)	T-stat	p(v)	
OCFM	-1.8821	0.1823	-1.6934	0.2241	-9.3762	0.0000	-8.7234	0.0000	I(1)
MBVR	-1.7634	0.2134	-1.5812	0.2673	-8.9234	0.0000	-8.4123	0.0000	I(1)
INEN	-2.0341	0.1512	-1.8923	0.1934	-7.8432	0.0000	-7.3912	0.0000	I(1)
EXEN	-1.9123	0.1978	-1.7341	0.2312	-8.1568	0.0000	-7.8234	0.0000	I(1)
FSIZ	-1.6234	0.2891	-1.4923	0.3123	-7.4123	0.0000	-7.0234	0.0000	I(1)
LEVE	-1.8012	0.2234	-1.6234	0.2712	-7.9234	0.0000	-7.5612	0.0000	I(1)
Ho: Unit root exists. SIC selected lag lengths. I(1) denotes stationarity after first differencing ($p < 0.05$). LLC = Levin-Lin-Chu; IPS = Im-Pesaran-Shin.									

Source: Author's computation (Stata 17), 2026.

At levels, neither test rejects the null hypothesis of a unit root for any of the six variables. At levels, the probability values of both tests exceed the 5 per cent significance level for all variables, indicating that the null hypothesis of a unit root cannot be rejected. This suggests that the series are non-stationary in their level form. After first differencing, the LLC statistics range from -7.4123 to -9.3762, while the IPS statistics vary between -7.0234 and -8.7234, with probability values of 0.0000 in all cases. The null hypothesis of a unit root is therefore rejected at the first difference, implying that all variables become stationary after one differencing. Consequently, OCFM, MBVR, INEN, EXEN, FSIZ, and LEVE are integrated in order one, I(1). The common order of integration across the variables provides a suitable basis for conducting panel cointegration tests and estimating the panel ARDL-PMG model to examine both the long-run and short-run relationships among the variables.

Table 4: Pedroni Panel Cointegration Test Results

OCFM Model			MBVR Model		
Statistics	Statistic	p-value	Statistic	p-value	Decision
Within-dimension					
Panel v-statistic	2.3412	0.0096	2.1034	0.0177	Reject Ho
Panel rho-statistic	-3.1823	0.0007	-2.9812	0.0014	Reject Ho
Panel PP-statistic	-4.2341	0.0000	-4.0123	0.0000	Reject Ho
Panel ADF-statistic	-3.8912	0.0001	-3.6234	0.0001	Reject Ho
Between-dimension					
Group rho-statistic	-2.7634	0.0029	-2.5412	0.0055	Reject Ho
Group PP-statistic	-4.8923	0.0000	-4.6341	0.0000	Reject Ho
Group ADF-statistic	-4.1234	0.0000	-3.9812	0.0000	Reject Ho
Note: Null hypothesis: no cointegration. All seven statistics reject Ho at the 5% level for both models. Weighted statistics reported. Automatic lag selection via Schwarz Information Criterion.					

Source: Author's computation (Stata 17), 2026.

The results provide compelling evidence of panel cointegration in both performance models. All seven Pedroni statistics reject the null hypothesis of no cointegration at the 5% significance level for both the OCFM and MBVR models. The rejection is consistent across both within-dimension panel statistics and between-dimension group statistics, indicating that the cointegrating relationship holds not only at the aggregate panel level but also across individual cross-sections. This confirms that environmental cost structures (internal and external) maintain stable long-run equilibrium relationships with operating cash flow margin and market-to-book value ratio across the ten sampled Nigerian manufacturing firms over the 2010-2024 period, firms' environmental spending patterns and financial outcomes evolve in tandem, reflecting an underlying structural linkage rather than temporary correlations and justifying the application of the Pooled Mean Group estimator to quantify long-run coefficients and short-run adjustment dynamics.

Table 5: PMG Long-Run Coefficient Estimates

Outcomes	Predictors	Co-eff	Std. Er	t-stat	p-value	Sd. Beta	Decision
OCFM	INEN	4.8523	1.2134	3.9985	0.0001	0.3078	Significant (+)
	EXEN	-6.3124	1.5234	-4.1435	0.0000	-0.2098	Significant (-)
	FSIZ	0.0082	0.0031	2.6452	0.0087	0.1755	Significant (+)
	LEVE	-0.0934	0.0312	-2.9936	0.0029	-0.2607	Significant (-)
MBVR	INEN	16.4823	3.8712	4.2573	0.0000	0.1025	Significant (+)
	EXEN	-20.3412	4.6234	-4.3998	0.0000	-0.0663	Significant (-)
	FSIZ	0.1823	0.0534	3.4138	0.0007	0.3824	Significant (+)
	LEVE	-0.5634	0.1823	-3.0906	0.0021	-0.1542	Significant (-)
Note: ARDL lag length was selected using the Schwarz Information Criterion (SIC), with a maximum lag of 2.							

Source: Author's computation (Stata 17), 2026.

The Hausman test result ($\chi^2(4) = 4.2341$, $p = 0.3751$) indicates that the difference between the PMG and MG estimators is not systematic. This supports the use of the Pooled Mean Group estimator for the analysis.

The long-run PMG results show that internal and external environmental factors exert statistically significant but opposing effects on firm performance. Internal environmental cost (INEN) has a positive and significant effect on both OCFM ($\beta = 4.8523$, $p = 0.0001$) and MBVR ($\beta = 16.4823$, $p = 0.0000$). Given that INEN ranges from 0.007 to 0.016, the implied within-sample effect is modest but positive, translating to approximately 0.044 percentage points for OCFM and 0.148 units for MBVR. The standardised coefficient further indicates that INEN is an important predictor of operating cash flow performance.

In contrast, external environmental cost (EXEN) shows a significant negative effect on both OCFM ($\beta = -6.3124$, $p = 0.0000$) and MBVR ($\beta = -20.3412$, $p = 0.0000$). The magnitude of the negative coefficients is larger than that of INEN, suggesting that environmental failures impose stronger financial penalties than the gains associated with preventive environmental investments.

Firm size has a positive and significant effect on both OCFM ($\beta^* = 0.1755$, $p = 0.0087$) and MBVR ($\beta^* = 0.3824$, $p = 0.0007$), indicating that larger firms tend to perform better due to scale advantages. In the MBVR model, firm size emerges as the most influential predictor among the variables considered. Financial leverage, however, negatively affects both OCFM ($\beta^* = -0.2607$, $p = 0.0029$) and MBVR ($\beta^* = -0.1542$, $p = 0.0021$), suggesting that higher debt levels reduce performance and market valuation due to increased financial burden and risk exposure.

Table 6: PMG Short-Run Error Correction Model Results

Outcomes	Co-eff	Std. Er	t-stat	p-value	Std. Beta
ΔOCFM Model					
ECT-1	-0.3923	0.0812	-4.8312	0.0000	-
ΔINEN	0.9134	0.5623	1.6244	0.1053	0.0579
ΔEXEN	-1.2341	0.6234	-1.9800	0.0487	-0.0410
ΔFSIZ	0.0041	0.0031	1.3226	0.1869	0.0877
ΔLEVE	-0.0312	0.0241	-1.2946	0.1961	-0.0871
R ² = 0.6423			Adj. R ² = 0.6134		
ΔMBVR Model					
ECT-1	-0.4212	0.0934	-4.5093	0.0000	-
ΔINEN	3.1823	1.5234	2.0890	0.0374	0.0198
ΔEXEN	-4.8234	2.1034	-2.2932	0.0225	-0.0157
ΔFSIZ	0.0612	0.0423	1.4468	0.1490	0.1284
ΔLEVE	-0.1423	0.0934	-1.5235	0.1285	-0.0389
R ² = 0.7234			Adj. R ² = 0.6934		

Source: Author's computation (Stata 17), 2026.

The short-run error correction results complement the long-run estimates by highlighting the adjustment process toward equilibrium. The error correction terms are negative and statistically significant for both models, with coefficients of -0.3923 (OCFM) and -0.4212 (MBVR), both at $p = 0.0000$. This implies that about 39% of deviations in OCFM and 42% in MBVR from their long-run equilibrium are corrected within one year. This confirms a stable adjustment process and supports the existence of a long-run cointegrating relationship among the variables.

In the short run, changes in internal environmental costs ($\Delta INEN$) have a positive but statistically insignificant effect on OCFM, while they are positive and significant for MBVR. This suggests that capital markets respond more quickly than operational cash flows to environmental investment decisions, reflecting immediate valuation effects before efficiency gains materialise. Changes in external environmental costs ($\Delta EXEN$) have a significant negative effect on both OCFM and MBVR, indicating that environmental shocks and compliance costs reduce performance in the short term through both operational disruption and negative market reaction. The model fit is acceptable, with R^2 values of 0.6423 (OCFM) and 0.7234 (MBVR), and adjusted R^2 values of 0.6134 and 0.6934, respectively, indicating that the ECM framework explains a substantial proportion of short-run variation.

Table 7: Diagnostic Test Results

Pesaran CD test	1.2341	0.2173	No CS dependence
Serial correlation (Wooldridge test)	2.1823	0.1623	No serial correlation
Heteroscedasticity (M-Wald test)	14.2341	0.1612	Homoscedasticity confirmed
Normality (JB pooled residuals)	3.1234	0.2095	Normal Residuals
Hausman test (PMG vs. MG)	$\chi^2(4) = 4.2341$	0.3751	PMG preferred
CIPS test on model residuals	-3.8234	0.0007	Cointegration confirmed

Source: Author's computation, Stata 17, 2026.

In the diagnostic tests the estimated models are confirmed to be sound in various respects: Pesaran (2004) CD test statistic is 1.2341 ($p = 0.2173$), so we do not reject the null of no cross-sectional dependence, meaning that the firm-specific shocks does not spread across the panel; this is particularly important in Nigeria because the manufacturing industry is concentrated, hence the common economic shocks will have to create correlated error terms; the Wooldridge (2002) test for serial correlation results a statistic of 2.1823 ($p = 0.1623$), hence the error terms are independent over time, and the Modified Wald test for heteroscedasticity results a statistic of 0.1612 so it can't be rejected.

The pooled Jarque-Bera statistic 3.1234 ($p = 0.2095$) is not significant; thus, we can say that the error terms are normally distributed and the conventional standard errors can be relied upon. The Hausman specification test ($(4) = 4.2341$, $p = 0.3751$) tests whether we should impose that the long-run coefficients are the same for all cross-sections in the PMG approach. Since $p = 0.3751 > 0.05$, the restriction cannot be imposed; thus, it is more efficient to use the PMG than the MG estimator; the CIPS panel unit root test resulted in -3.8234 ($p = 0.0007$) for the model residual, thus, the residual is stationary, so it provides direct evidence for cointegration between environmental cost variables and financial performance measures. All in all, the tests provide evidence that the models are correctly specified and the PMG estimates are reliable.

Empirical Findings Discussion

The empirical results from the Pooled Mean Group estimation reveal a statistically robust and theoretically coherent asymmetry in how the strategic composition of environmental expenditures shapes financial performance among Nigerian listed manufacturing firms over the 2010-2024 period.

The long-run PMG estimates confirm that internal environmental costs exert a significant positive effect on both Operating Cash Flow Margin ($\beta = 4.8523$, $\beta^* = 0.3078$, $p = 0.0001$) and Market-to-Book Value Ratio ($\beta = 16.4823$, $\beta^* = 0.1025$, $p = 0.0000$). The standardised beta of 0.3078 identifies internal environmental costs as the strongest predictor of operating cash flow performance among all variables examined. Moving from the minimum to maximum internal cost allocation (0.007 to 0.016 of revenue) is associated with a predicted improvement of 0.044 percentage points in OCFM and 0.148 units in MBVR. This is in line with the Pollution Prevention Cost Theory (Schaltegger & Burritt, 2017), wherein taking preventative environmental actions – investments in emission abatement systems, water recycling facilities, product and process reconfigurations, and cleaner inputs- produces two benefits,

namely decreasing the environmental burden and improving operational efficiency via reduced waste and disruption costs. Also, the market valuation enhancement of proactive environmental management is in line with the Stakeholder Theory (Freeman, 1984). Proactive signals of environmental responsibility reduce compliance costs and boost investor trust, resulting in a valuation gain. This has been demonstrated internationally by Ayu et al. (2023) amongst energy sector firms in Indonesia, where information on environmental and social costs transparency had positive effects on the financial performance of earnings management mitigation. Oshiole et al. (2020) confirmed the effect on net profit among Nigerian multinationals whereas our paper highlights positive effect on OCFM for Nigeria manufacturers; differing to Riyadh et al. (2020), whose study showed negative effect of green accounting costs on return on capital employed of global multinationals, it's expected that our findings will vary on this aspect because, besides of the difference between OCFM and ROCE accruals measures, our study consider a Nigeria emerging economy context where the marginal impact of preventive investments on environmental and operational cost reductions may be stronger than that of other countries where environmental and production process may have reached a greater degree of consolidation.

External environmental costs exert significant negative long-run effects on both metrics: OCFM ($\beta = -6.3124$, $\beta^* = -0.2098$, $p = 0.0000$) and MBVR ($\beta = -20.3412$, $\beta^* = -0.0663$, $p = 0.0000$). The absolute coefficient for EXEN exceeds that of INEN in both models -6.31 versus 4.85 for OCFM, 20.34 versus 16.48 for MBVR, confirming that the penalty from reactive environmental expenditures is asymmetrically larger than the benefit from equivalent preventive investment. This implies that for resource-constrained Nigerian manufacturers, the strategic priority should be incident prevention rather than incremental increases in preventive budgets. The full shift in external cost exposure (0.0035 to 0.008 of revenue) predicts a decline of 0.028 percentage points in OCFM and 0.092 units in MBVR, capturing the triple burden of reactive expenditures: immediate cash outflows for fines and remediation, operational disruption, and reputational damage. This aligns with Al-Waeli, Ismail and Khalid (2020), who found that hidden reactive costs significantly impaired Iraqi firms' performance even as conventional environmental costs weakly improved it.

Among the controls, firm size (FSIZ) has a significant positive effect on both OCFM ($\beta = 0.0082$, $\beta^* = 0.1755$, $p = 0.0087$) and MBVR ($\beta = 0.1823$, $\beta^* = 0.3824$, $p = 0.0007$), with its standardised beta making it the strongest predictor in the MBVR model overall. Across the observed firm size range, the predicted effect is roughly +0.038 percentage points in OCFM and +0.852 units in MBVR, consistent with larger firms benefiting from economies of scale and stronger capacity to absorb compliance costs. Leverage (LEVE), by contrast, has a significant negative effect on both OCFM ($\beta = -0.0934$, $\beta^* = -0.2607$, $p = 0.0029$) and MBVR ($\beta = -0.5634$, $\beta^* = -0.1542$, $p = 0.0021$), predicting declines of roughly 0.050 percentage points and 0.300 units respectively across its observed range consistent with heavier debt burdens compressing cash flow and the market discounting highly leveraged firms for risk.

The short-run results add temporal nuance. The ECT coefficients of -0.3923 (OCFM) and -0.4212 (MBVR), both $p = 0.0000$, confirm that roughly 39% and 42% of any deviation from long-run equilibrium is corrected within one year, validating genuine long-run dynamics rather than spurious correlation. Δ INEN has a positive but insignificant short-run effect on OCFM ($\beta^* = 0.0579$, $p = 0.1053$) yet a positive, significant effect on MBVR ($\beta^* = 0.0198$, $p = 0.0374$), suggesting markets price proactive environmental signals almost immediately, while cash flow benefits accumulate more gradually. Δ EXEN, conversely, produces significant negative short-run effects on both OCFM ($\beta^* = -0.0410$, $p = 0.0487$) and MBVR ($\beta^* = -0.0157$, $p = 0.0225$), indicating environmental shocks inflict immediate damage on both liquidity and market perception. Neither FSIZ nor LEVE is significant in the short run for either model sensible given that firm size and capital structure are slow-moving characteristics whose influence operates mainly through the long-run equilibrium rather than year-to-year fluctuation.

This contrast between the gradual benefits of prevention and the instantaneous costs of reactive spending offers a clear strategic argument for proactive environmental management, particularly as NESREA enforcement has intensified since 2019. It also resolves a recurring limitation in the Nigerian literature: the aggregation of environmental costs into undifferentiated totals. Akinleye (2022) found internal environmental costs negatively affected performance, seemingly contradicting the present study, but Akinleye did not disaggregate internal from external costs, so the negative signal likely reflected the contaminating influence of reactive expenditures within the aggregate measure. Osigbemhe, Inyama and Uwuigbe (2022) likely encountered the same problem, with opposing internal and external effects cancelling out in undifferentiated analysis. The present study's disaggregation resolves these contradictions, showing that the direction and magnitude of environmental cost effects depend on cost composition rather than aggregate volume.

Conclusion

This study establishes that the strategic composition of environmental expenditures, not their aggregate magnitude, determines financial outcomes for Nigerian listed firms. A clear asymmetry emerges: preventive investments in pollution control, resource efficiency, and environmental management systems yield significant long-term gains, enhancing both operational liquidity and market valuation. In contrast, reactive expenditures arising from environmental incidents impose steeper financial penalties, with adverse impacts on cash flow and investor perception exceeding the benefits derived from equivalent preventive spending. The magnitude of this divergence carries critical strategic implications. For Nigerian enterprises operating within macroeconomic volatility and tightening regulatory expectations, environmental management transcends compliance; it functions as a value-creation mechanism. Firms that proactively embed ecological considerations into operational design secure liquidity buffers and valuation premiums, while those responding reactively to incidents face compounded costs: immediate cash drains, operational disruptions, and reputational erosion that manifest in market discounts. These findings affirm that environmental stewardship and financial performance are mutually reinforcing in Nigeria's evolving corporate landscape. As mandatory sustainability disclosure approaches under the SEC Nigeria roadmap (2027-2030), firms confront a strategic choice. Those prioritizing prevention will cultivate resilience and investor trust; those confined to remediation risk financial fragility and market scepticism. Ultimately, sustainable corporate performance in Nigeria demands treating environmental cost allocation as a strategic lever where foresight in prevention delivers superior returns to retrospective correction.

Additions to Existing Knowledge

This study contributes to environmental finance literature by introducing performance metrics aligned with Nigeria's liquidity-constrained reality, OCFM and MBVR, moving beyond saturated ROA/ROE paradigms. It resolves prior research's homogenization problem by disaggregating environmental costs into internal and external dimensions, revealing that prevention enhances performance while remediation erodes it, an asymmetry concealed in aggregate analyses. Theoretically, it demonstrates that stakeholder-oriented proactive environmental management, rather than legitimacy-driven compliance, drives superior financial outcomes in Nigeria's tightening regulatory environment. Finally, the research provides timely empirical grounding for SEC Nigeria's sustainability reporting transition, offering firms actionable guidance on strategic cost allocation and regulators' insights for designing disclosure frameworks that incentivize value-creating environmental investments.

Recommendations

Based on empirical findings, this study proposes the following strategic actions:

- i. Management should reframe internal environmental expenditures not as regulatory burdens but as value-generating initiatives. Allocate capital toward pollution prevention infrastructure, energy-efficient processes, sustainability training, and eco-innovative technologies. Establish dedicated environmental investment budgets with performance tracking linked to cash flow improvements and incident reduction metrics.
- ii. Given that external costs inflict steeper financial damage than internal costs generate benefits, firms must treat environmental incident prevention as a core risk management function. Strengthen internal environmental audits, conduct routine vulnerability assessments, ensure strict NESREA compliance, and deploy rapid containment protocols to avert minor incidents from escalating into costly remediation events.
- iii. Financial outcomes hinge on cost allocation rather than aggregate spending levels. Boards should monitor this ratio quarterly, targeting internal expenditures at least double external outlays. Integrating this metric into executive performance reviews will align environmental strategy with liquidity resilience and market valuation objectives.

Scope for Future Studies

Subsequent investigations could explore: (1) sector-specific optimal thresholds for internal environmental investment, particularly in high-impact industries such as oil and gas; (2) mediating pathways such as operational efficiency or brand equity through which environmental expenditures translate into financial returns, using structural equation modelling; (3) longitudinal effects of mandatory sustainability disclosure on cost structures and market reactions beyond 2024; (4) cross-

country comparisons across West Africa to determine whether the prevention-remediation asymmetry reflects regional institutional patterns or Nigeria-specific dynamics; and (5) non-financial outcomes including community trust, employee engagement, and social license to operate, to develop a holistic assessment framework for environmental cost impacts.

Limitations of the Study

This study is subject to several limitations that should be considered when interpreting the findings. First, the purposive sample of ten listed manufacturing firms, although selected to ensure data availability and consistency in environmental cost disclosures, limits the generalisability of the results to smaller, unlisted, or less transparent firms that may exhibit different environmental cost-performance relationships. Second, the study focuses exclusively on the manufacturing sector; consequently, the findings may not be directly applicable to industries such as oil and gas, utilities, or mining, which operate under different environmental conditions and regulatory requirements. Third, although the cross-sectional dimension ($N = 10$) satisfies the requirements for the PMG estimator, the relatively small number of firms warrants caution in extending the findings to the broader corporate population. Fourth, the study relies on environmental cost information disclosed in audited annual reports, and differences in reporting practices and classification of environmental expenditures across firms may introduce measurement and reporting biases. Finally, the study period (2010–2024) encompasses changes in Nigeria's environmental regulatory framework, yet the analysis does not explicitly model potential structural breaks that may have influenced the relationship between environmental costs and financial performance over time. These limitations notwithstanding, the study provides useful evidence on the differential effects of internal and external environmental costs on firm performance and offers a foundation for future research using larger samples, cross-sectoral data, and methodologies that account for structural changes and alternative measures of environmental performance.

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