

Environmental Accounting Practices and Firm Profitability: A Granger Causality Analysis of Nigerian Manufacturing Firms

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Abstract

This study examines the temporal relationship between environmental accounting practices and the profitability of listed manufacturing firms in Nigeria over the period 2016–2024. Using balanced panel data from 12 firms, the study employs descriptive analysis, panel regression techniques, panel cointegration tests, and Granger causality analysis to explore whether environmental accounting practices are systematically associated with firm performance over time. Environmental accounting practices are proxied by waste management expenditure, pollution control investment, environmental reporting, carbon accounting disclosure, and environmental training, while profitability is measured using return on assets (ROA), return on equity (ROE), and Tobin's Q. The empirical results indicate that environmental accounting practices are positively and statistically associated with firm profitability across alternative performance measures. Granger causality tests suggest a unidirectional temporal relationship running from environmental accounting practices to profitability, indicating that past environmental practices contain information useful for predicting future financial performance. Robustness checks confirm the stability of the results across alternative specifications. The findings suggest that environmental accounting practices are not merely compliance-oriented activities but are associated with favourable financial outcomes over time. However, the results are interpreted as evidence of predictive and temporal relationships rather than definitive structural causation. The study contributes to the emerging literature on sustainability accounting in developing economies and provides policy-relevant insights for corporate managers and regulators.

Keywords: Environmental Accounting, Profitability, Granger Causality, Sustainability Reporting

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Introduction

In recent decades, environmental concerns have become a major global issue, compelling organizations to adopt practices that integrate sustainability into business operations. Environmental accounting (E-accounting), often referred to as green accounting, has emerged as a vital tool for measuring, reporting, and disclosing the environmental costs and benefits of corporate activities. It goes beyond traditional financial reporting by incorporating environmental costs, such as waste management, pollution control, resource depletion, and energy consumption, into financial decision-making (Bose et al., 2022). This approach allows firms to assess the true cost of production and evaluate their impact on the ecosystem, aligning corporate goals with sustainable development objectives.

Manufacturing firms in particular face mounting pressure to adopt environmental accounting practices due to their resource-intensive operations and contribution to environmental degradation (Adewuyi & Olanrewaju, 2023). Stakeholders, including regulators, investors, and civil society, increasingly demand greater transparency and accountability regarding firms' environmental performance. Consequently, organizations that embed environmental accounting practices are better positioned to manage risks, reduce costs, and enhance their corporate image (Okafor & Adeleke, 2022).

In the Nigerian context, environmental challenges such as gas flaring, industrial emissions, and poor waste disposal practices highlight the need for robust environmental reporting mechanisms. Despite the existence of regulatory frameworks like the National Environmental Standards and Regulations Enforcement Agency (NESREA) Act, many manufacturing firms lag in environmental disclosure and compliance (Oluwagbemiga, 2021). Integrating environmental accounting in financial systems thus represents not only compliance with global best practices but also a pathway to long-term sustainability.

Profitability remains a central indicator of corporate success and sustainability. For manufacturing firms, profitability determines their ability to sustain operations, attract investments, and create value for stakeholders (Ijeoma & Aronu, 2019). However, the relationship between environmental accounting and profitability has generated debate in both academic and professional circles. Some scholars argue that environmental accounting practices increase operational costs due to investments in clean technology, waste management, and compliance reporting (Mensah et al., 2023). Conversely, others contend that adopting sustainable practices can enhance efficiency, reduce resource wastage, and improve brand reputation, which in turn positively affects financial performance (Adebayo & Okonjo, 2023).

Understanding the causal relationship between environmental accounting and profitability is particularly significant for developing economies like Nigeria, where firms often face the dual challenge of maximizing shareholder wealth while addressing environmental concerns. If environmental accounting can indeed contribute to long-term profitability, it offers a strategic opportunity for manufacturing firms to align financial performance with sustainable development goals (Ezejiofor et al., 2020). This study, therefore, seeks to investigate the causal link between environmental accounting practices and profitability in selected Nigerian manufacturing firms, providing empirical evidence to enrich both academic discourse and managerial practice.

Statement of the Problem

The growing emphasis on environmental sustainability has compelled firms to adopt environmental accounting practices, which often involve significant investments in waste treatment, pollution control, renewable energy adoption, and environmental disclosure. While these practices are necessary for mitigating environmental risks and ensuring compliance with both national and international regulations, they also impose substantial costs on firms. This raises a critical question: do these investments enhance firm profitability, or do they remain largely compliance-driven expenditures without direct financial benefits (Mensah et al., 2023).

Globally, empirical studies have produced mixed evidence. Some scholars argue that environmental accounting contributes to long-term profitability by reducing inefficiencies, enhancing corporate image, and attracting sustainability-conscious investors (Bose et al., 2022). Others, however, maintain that these practices increase operating costs, potentially eroding profitability in the short run, particularly in competitive markets (Adebayo & Okonjo, 2023).

In Nigeria, the debate is even more pronounced due to weak regulatory enforcement, limited stakeholder pressure, and the absence of standardized environmental accounting frameworks. Although prior studies have examined sustainability disclosures and firm performance in Nigeria (Oluwagbemiga, 2021; Adewuyi & Olanrewaju, 2023), the majority have taken a general sustainability perspective without specifically isolating environmental accounting practices. Furthermore, much of the existing research is descriptive and fails to establish a clear causal relationship between environmental accounting and profitability in manufacturing firms (Ezejiofor et al., 2020).

This gap in the literature is critical given that manufacturing firms are among the largest contributors to environmental degradation in Nigeria, yet conclusive evidence on whether their environmental practices enhance profitability remains scarce. The lack of empirical studies focusing on

the causal relationship between environmental accounting practices and profitability has created uncertainty among managers, who may view such initiatives as unnecessary compliance costs rather than strategic investments. This gap, therefore, provides strong justification for this study, which seeks to investigate the causal relationship between environmental accounting practices and profitability in selected Nigerian manufacturing firms. By doing so, the study aims to provide evidence-based insights that can inform both managerial decision-making and public policy formulation.

Research Objectives

- i. To examine the extent of environmental accounting practices adopted by selected manufacturing firms in Nigeria.
- ii. To investigate the causal relationship between environmental accounting practices and the profitability of manufacturing firms in Nigeria.
- iii. To determine whether environmental accounting investments serve primarily as compliance costs or as strategic tools for enhancing financial performance in Nigerian manufacturing firms.

Research Questions

1. To what extent do selected manufacturing firms in Nigeria adopt environmental accounting practices?
2. What is the causal relationship between environmental accounting practices and profitability in Nigerian manufacturing firms?
3. Do investments in environmental accounting represent compliance-driven costs or strategic drivers of profitability for manufacturing firms in Nigeria?

Research Questions

H1: Selected manufacturing firms in Nigeria do not significantly adopt environmental accounting practices.

H2: There is no significant causal relationship between environmental accounting practices and the profitability of manufacturing firms in Nigeria.

H3: Investments in environmental accounting represent only compliance-driven costs and do not significantly enhance the profitability of Nigerian manufacturing firms.

Literature Review

Conceptual Review

Environmental Accounting Practices

Environmental accounting practices (EAPs) have become an essential component of corporate governance, reporting, and strategic management. They provide organizations with tools to measure, monitor, and disclose how their operations interact with and impact the natural environment. Unlike conventional accounting systems that primarily emphasize financial performance, EAPs integrate ecological costs, resource efficiency, and sustainability considerations into decision-making. This multidimensional approach enables firms to align financial objectives with environmental stewardship, thereby enhancing both corporate accountability and long-term competitiveness (Agyemang & Yensu, 2021; Adams & Frost, 2021).

The importance of environmental accounting is increasingly recognized in both developed and developing economies. Global regulatory trends, stakeholder pressures, and sustainable development goals (SDGs) have heightened the demand for firms to embed environmental concerns into their financial systems. Scholars argue that adopting EAPs enhances organizational resilience against environmental risks, strengthens corporate legitimacy, and fosters investor confidence in sustainability-oriented markets (López-Arceiz et al., 2018; Mensah & Opong, 2022).

Key Elements of Environmental Accounting Practices

Waste Management

Waste management is one of the most visible aspects of EAPs. Manufacturing firms often produce large quantities of waste—solid, liquid, and gaseous—which, if not managed effectively, can create significant ecological and reputational risks. Waste accounting captures the costs associated with waste generation and disposal, creating transparency around resource inefficiencies (Christ & Burritt, 2019). Effective strategies include reduction at source, recycling, reuse of by-products, and adoption of circular economy practices. Recent studies show that firms that embed waste management into accounting frameworks achieve not only environmental compliance but also financial gains through resource efficiency and cost savings (Olatunji & Jimoh, 2022; Ambe & Nguyen, 2022).

Pollution Control

Pollution control extends beyond compliance with environmental regulations to proactive investment in cleaner technologies and emission reduction systems. Firms often allocate resources to install abatement equipment, redesign production processes, and adopt cleaner fuels. Although such

measures may raise short-term costs, they reduce exposure to environmental penalties, litigation, and reputational crises (Nguyen & Tran, 2023). Furthermore, pollution control enhances firms' social license to operate, particularly in regions where community opposition to environmentally harmful practices is strong (Clarkson et al., 2019; Dutta et al., 2021). Pollution accounting provides data on the costs of emissions, effluents, and remediation, thereby supporting management in making informed trade-offs between environmental investments and financial performance.

Environmental Reporting

Environmental reporting, also called environmental disclosure, is the process of communicating firms' environmental performance to stakeholders through sustainability reports, integrated reports, or stand-alone environmental statements. Such disclosures reduce information asymmetry between firms and their stakeholders, enhancing corporate transparency and legitimacy (Mousa & Hassan, 2021). Investors increasingly rely on environmental reporting to assess climate-related risks and ESG performance (Alfaro & Rodríguez, 2020). Empirical research indicates that firms with higher levels of environmental disclosure enjoy stronger market valuation, improved access to capital, and enhanced stakeholder trust (Ioannou & Serafeim, 2017; Osei & Boateng, 2023).

Carbon Accounting

Carbon accounting, also known as greenhouse gas (GHG) accounting, has gained prominence in response to global climate change debates and policy frameworks like the Paris Agreement. It involves measuring and reporting the carbon footprint of firms' operations, including direct and indirect emissions. Firms that adopt carbon accounting benefit from better risk management, eligibility for carbon credits, and alignment with investor-driven ESG requirements (Okeke & Udeh, 2023). Carbon accounting also supports internal decision-making by identifying high-emission processes and opportunities for energy efficiency (Akinwale & Adewumi, 2022). Importantly, studies show that carbon disclosure is positively correlated with firm reputation, competitiveness, and long-term profitability in carbon-intensive industries (Schaltegger & Burritt, 2018; Adams & Frost, 2021).

Together, these environmental accounting practices enable firms to internalize environmental costs previously treated as externalities. By doing so, firms not only comply with regulations but also achieve cost efficiency, enhance competitiveness, and strengthen corporate reputation (Gray & Milne, 2015; Mensah & Oppong, 2022).

Profitability

Profitability remains a cornerstone of corporate performance evaluation. It reflects how efficiently a firm generates returns relative to the resources employed. In environmental accounting research, profitability is often examined through both accounting-based indicators (such as Return on Assets and Return on Equity) and market-based measures (such as Tobin's Q), providing a multidimensional assessment of performance (Umar & Hassan, 2021).

Return on Assets (ROA)

ROA measures how effectively firms convert their assets into profits. It is particularly useful for analysing whether investments in eco-friendly practices enhance asset utilization. Empirical studies suggest that firms that adopt waste reduction and energy efficiency programs often achieve higher ROA because of improved resource productivity (Abubakar & Ibrahim, 2022).

Return on Equity (ROE)

ROE focuses on shareholder value creation by measuring net income relative to equity. It reflects management's efficiency in using shareholder capital. Evidence shows that firms engaging in sustainability reporting and environmental innovation attract more socially responsible investors, thereby strengthening ROE performance (Khan & Malik, 2020). Conversely, poor environmental practices can erode ROE through legal liabilities and reputational losses.

Tobin's Q

Tobin's Q is a forward-looking indicator that reflects market perceptions of firm value relative to asset replacement costs. High Tobin's Q ratios signal strong investor confidence and recognition of intangible assets such as sustainability and brand reputation. Research indicates that firms with robust environmental reporting and carbon disclosure are often rewarded with higher Tobin's Q, as markets increasingly incorporate environmental risk into valuation models (Osei & Boateng, 2023).

By integrating both internal efficiency measures (ROA, ROE) and market-based valuation measures (Tobin's Q), a holistic perspective of profitability emerges. This dual approach is essential for understanding how environmental accounting practices impact not only operational performance but also investor perceptions and long-term market value (Mensah & Oppong, 2022).

Theoretical Review

Stakeholder Theory

The stakeholder theory, developed by Freeman (1984), posits that organizations are accountable not only to shareholders but also to a broader set of stakeholders, including employees, customers, communities, regulators, and the natural environment. Firms are expected to adopt practices that address the expectations of these groups in order to secure legitimacy, social license to operate, and long-term sustainability. In the context of environmental accounting, this theory suggests that manufacturing firms engage in activities such as pollution control, waste management, and environmental disclosures to meet the growing demand for sustainability by external stakeholders (Deegan, 2019; Freeman et al., 2020). Compliance with environmental regulations and voluntary environmental reporting thus becomes a mechanism for firms to maintain trust, reduce reputational risks, and enhance stakeholder relations.

However, while stakeholder theory provides strong justification for why firms adopt environmental accounting practices, it does not adequately explain whether such practices translate into improved profitability. The theory emphasizes external legitimacy and accountability but falls short of establishing a direct causal link between environmental practices and financial performance (Uwuigbe et al., 2021). This gap highlights the need for a complementary theoretical perspective.

Resource-Based View (RBV)

The resource-based view (RBV), articulated by Barney (1991), focuses on how firms develop and leverage internal resources and capabilities to achieve competitive advantage. According to this perspective, environmental accounting practices—such as carbon accounting, energy efficiency reporting, and pollution management—can be considered strategic resources when they are rare, valuable, inimitable, and non-substitutable (Hart, 1995; Russo & Fouts, 1997). By internalizing environmental strategies, firms can reduce operational costs, improve efficiency, enhance innovation, and ultimately strengthen financial performance. For example, investment in waste reduction initiatives may not only demonstrate compliance but also lower production costs, thereby improving profitability.

Unlike stakeholder theory, RBV explicitly connects environmental practices with economic gains and competitiveness. It shifts the focus from compliance and legitimacy to strategic advantage, suggesting that firms that integrate sustainability into their core processes are more likely to realize superior profitability (Albertini, 2017).

Interrelationship of Theories

The interplay between stakeholder theory and RBV provides a more holistic explanation of the relationship between environmental accounting and profitability. Stakeholder theory explains the motivation behind environmental accounting adoption—meeting societal and regulatory expectations—while RBV explains the outcome of such adoption in terms of competitive advantage and improved financial performance. In other words, stakeholder pressure may drive firms to adopt environmental practices, but only firms that strategically integrate these practices as internal resources can translate them into profitability (Aragón-Correa & Sharma, 2003).

Thus, the gap in stakeholder theory—the lack of explanation of financial implications—necessitates the incorporation of RBV, which addresses this limitation by emphasizing resource efficiency and long-term financial value. This theoretical complementarity provides a strong justification for investigating the causal relationship between environmental accounting practices and profitability in the Nigerian manufacturing sector.

Empirical Review

Environmental Accounting Practices and Firm Profitability

Empirical evidence on the nexus between environmental accounting practices (EAPs) and firm profitability has produced varied insights. Several studies demonstrate that waste management initiatives such as recycling, cleaner production, and eco-efficiency can lower operating costs and enhance profitability. For instance, Chen et al. (2020) found that Chinese manufacturing firms that invested in waste reduction recorded higher return on assets (ROA) due to reduced material costs and improved resource efficiency. Similarly, Adegbe and Adeniji (2021) emphasized that Nigerian listed firms that adopted systematic waste management policies experienced reduced regulatory fines and enhanced reputation, which translated into improved profitability.

Pollution control practices also remain central to environmental accounting. Empirical evidence suggests that investment in pollution abatement not only reduces compliance risks but also strengthens financial outcomes. Orazalin (2022), using panel data from emerging markets, showed that firms implementing stringent pollution control systems enjoyed higher Tobin's Q, suggesting a positive valuation effect from investors. In the Nigerian context, Uwuigbe et al. (2020) confirmed that pollution reduction disclosures positively influenced return on equity (ROE), thereby demonstrating that socially responsible environmental accounting practices enhance financial performance.

Environmental Reporting, Carbon Accounting, and Profitability

Environmental reporting has become a critical mechanism for linking sustainability practices with firm performance. Studies indicate that comprehensive environmental disclosures strengthen transparency and stakeholder trust, which enhances profitability. For instance, Adebayo and Okonjo (2023) found that Nigerian firms with detailed sustainability reporting practices exhibited significantly higher earnings per share, suggesting that environmental disclosure plays a mediating role in profitability. Similarly, Kılıç and Kuzey (2019) provided cross-country evidence from Turkey that voluntary carbon reporting increased market valuation, reflecting investor appreciation of carbon accounting practices.

Carbon accounting, in particular, has drawn scholarly interest as firms face pressure to quantify and disclose greenhouse gas emissions. Empirical results by Khan et al. (2021) indicated that Asian firms engaging in carbon disclosure experienced improved ROA and ROE due to reputational benefits and better alignment with international investors. In Sub-Saharan Africa, Okafor and Adeleke (2022) revealed that firms reporting on carbon emissions experienced stronger profitability metrics, especially in industries with higher environmental footprints such as cement and oil refining.

Profitability Measures and Environmental Practices

Most empirical studies employ ROA, ROE, and Tobin's Q as indicators of profitability. Evidence suggests that these profitability proxies are sensitive to the extent of environmental accounting adoption. For instance, Li et al. (2022) demonstrated that ROA significantly improved among environmentally proactive Chinese firms, while Tobin's Q captured investors' valuation of firms with transparent sustainability disclosures. On the other hand, Adeniran and Bello (2021) found that in Nigeria, the short-term profitability effects of environmental investments were weak, but long-term effects were positive, highlighting the temporal dimension of the relationship.

Moreover, research in Europe by García-Sánchez et al. (2021) stressed that environmental practices enhanced ROE through reputational advantages and cost savings, while in Africa, Okonkwo and Nwakoby (2023) highlighted that environmental disclosure was positively associated with ROA among listed manufacturing firms. These findings collectively suggest that environmental accounting practices, when strategically integrated, enhance both accounting-based and market-based measures of profitability.

Evidence Gap and Causality Dimension

While the empirical literature has extensively examined the association between environmental practices and profitability, a critical gap persists in terms of causal relationships. Most studies rely on correlation or regression analysis, which establishes association but not causality. Very few studies employ Granger causality tests to determine whether environmental practices drive profitability over time or whether profitability enables greater environmental investment. For example, Rahman and Masud (2021) in Bangladesh applied a time-series causality approach and revealed a unidirectional causal relationship from environmental disclosure to firm profitability. However, similar studies remain limited in the Nigerian context.

This gap justifies the present study, which applies the Granger causality approach to investigate whether environmental accounting practices predict profitability or vice versa in Nigerian manufacturing firms.

Methodology

Research Design

This study adopts a quantitative panel research design to examine the temporal relationship between environmental accounting practices and the profitability of listed manufacturing firms in Nigeria. The design is appropriate for analysing firm-level behaviour over time and allows for the application of panel regression techniques and Granger causality tests to explore predictive relationships among variables. Rather than asserting strict structural causality, the study focuses on temporal and directional associations between environmental accounting practices and firm performance.

Population of the Study

The population comprises all manufacturing firms listed on the Nigerian Exchange Group (NGX) between 2016 and 2024. These firms operate across diverse manufacturing sub-sectors, including food and beverages, cement, chemicals, and consumer goods, which are typically associated with significant environmental footprints and regulatory exposure.

Sample Size and Sampling Technique

A purposive sampling technique was employed to select firms with consistent and reliable environmental and financial disclosures over the study period. Out of approximately 30–35 listed manufacturing firms, 12 firms satisfied the following inclusion criteria:

- 1) Continuous listing on the NGX throughout the period 2016–2024;
- 2) Availability of complete annual financial statements for all years;
- 3) Explicit disclosure of at least one environmental accounting practice (waste management, pollution control, environmental reporting, or carbon accounting);
- 4) Absence of prolonged reporting gaps that could compromise the construction of a balanced panel dataset.

The restriction to firms with consistent disclosures was necessary to ensure methodological validity, particularly for panel cointegration and Granger causality analyses, which are sensitive to missing observations. Although the resulting sample size is modest, it enhances internal validity by reducing measurement error and disclosure-induced bias. Consequently, the findings are most applicable to the listed Nigerian manufacturing firms with relatively mature environmental reporting practices, and caution is required when generalising beyond this scope.

Data Type and Sources

The study relies exclusively on secondary panel data obtained from publicly available sources, including:

- 1) Annual financial statements of the sampled firms;
- 2) Sustainability and environmental disclosures contained within annual reports or standalone sustainability reports;
- 3) Nigerian Exchange Group (NGX) Factbook and firm investor-relations portals;
- 4) Supplementary environmental disclosures issued in line with regulatory requirements.

All data were manually cross-checked across reporting sections to ensure consistency and accuracy.

Variable Measurement and Operationalisation

Independent Variable: Environmental Accounting Practices (EAPs)

Environmental accounting practices were operationalised using five proxies derived from firms' financial and non-financial disclosures:

- Waste Management Expenditure (WME): Measured as the ratio of waste management-related expenditure to total operating expenses. Scaling by operating expenses enhances comparability across firms and mitigates size-related distortions.

- Pollution Control Investment (PCI): Measured as the absolute monetary value (₦) of pollution abatement and environmental protection investments disclosed in annual reports.
- Environmental Reporting (ER): A dummy variable coded as 1 if a firm disclosed a dedicated environmental or sustainability report consistent with recognised reporting frameworks (e.g., GRI), and 0 otherwise.
- Carbon Accounting Disclosure (CAD): A dummy variable coded as 1 if a firm disclosed quantitative or qualitative information on greenhouse gas emissions or carbon footprint, and 0 otherwise.
- Environmental Training and Awareness (ETA): Measured as the proportion of total staff training expenditure allocated to environmental and sustainability-related programmes.

The identification and coding of disclosure-based variables followed clearly defined criteria to enhance replicability and measurement validity.

Dependent Variable: Profitability

Firm profitability was measured using both accounting-based and market-based indicators:

- Return on Assets (ROA): Net income divided by total assets;
- Return on Equity (ROE): Net income divided by shareholders' equity;
- Tobin's Q: Market value of the firm divided by the replacement cost of assets.

Using multiple profitability measures provides a more comprehensive assessment of firm performance and strengthens robustness.

Control Variable

Firm Size (FS): Measured as the natural logarithm of total assets, included to control for scale effects and differences in resource capacity across firms.

Model Specification

The relationship between environmental accounting practices and profitability was examined using the following panel regression model:

$$\text{PROF}_{it} = \alpha_0 + \alpha_1 \text{WME}_{it} + \alpha_2 \text{PCI}_{it} + \alpha_3 \text{ER}_{it} + \alpha_4 \text{CAD}_{it} + \alpha_5 \text{ETA}_{it} + \alpha_6 \text{FS}_{it} + \mu_{it}$$

Where:

PROF_{it} = Profitability measures (ROA, ROE, Tobin's Q) of firm i at time t.

WME, PCI, ER, CAD, ETA = Environmental accounting practice proxies.

FS_it = Firm size (control variable).

μ_{it} = Error term.

Both fixed-effects and random-effects models were estimated, with the Hausman test used to determine the most appropriate model.

Method of Data Analysis

Data analysis proceeded in the following stages:

- 1) Descriptive statistics to summarise key characteristics of the variables;
- 2) Panel unit root tests (Levin–Lin–Chu and Im–Pesaran–Shin) to assess stationarity;
- 3) Panel cointegration tests (Pedroni and Kao) to examine long-run relationships;
- 4) Panel regression analysis using fixed- or random-effects models;
- 5) Granger causality tests to explore the temporal direction of relationships between environmental accounting practices and profitability;
- 6) Robustness checks using alternative profitability measures.

All analyses were conducted using EViews 12 and Stata 16.

Endogeneity and Methodological Limitations

The study recognises potential endogeneity concerns, including reverse causality and omitted variable bias. While firm fixed effects and lag structures in the Granger causality framework help mitigate these concerns, they do not entirely eliminate them. Accordingly, the results are interpreted as evidence of temporal and predictive relationships, rather than definitive structural causation.

Data Analysis and Presentation

Table 1. Descriptive Statistics

Variable	Mean	Median	Std. Dev	Min	Max
WME	0.046	0.045	0.02	0.01	0.085
PCI	12.8M	12.5M	6.1M	1.5M	26M
ER	0.76	1	0.43	0	1
CAD	0.57	1	0.49	0	1
ETA	0.033	0.031	0.018	0.005	0.065
ROA	0.085	0.083	0.026	0.042	0.136
ROE	0.121	0.118	0.041	0.065	0.187
Tobin's Q	1.36	1.34	0.43	0.85	2.16
FS	7.88	7.83	0.64	6.95	8.92

As shown in Table 1, firms allocate an average of 4.6 percent of operating expenses to waste management (WME), ranging from 1 percent to 8.5 percent, while pollution control investment (PCI) averages ₦12.8 million (₦1.5m–₦26m). Disclosure practices are moderate, with 76 percent of firms publishing sustainability reports (ER) and 57 percent providing carbon accounting disclosures (CAD). Environmental training and awareness (ETA) accounts for 3.3 percent of training budgets, with a maximum of 6.5 percent. Profitability indicators are strong, with ROA at 8.5 percent, ROE at 12.1 percent, and Tobin’s Q averaging 1.36, reflecting favorable market valuations. The average firm size (FS) is 7.88 (log of total assets), indicating the dominance of large corporations. Overall, Table 1 shows that while firms perform well financially, sustainability practices remain uneven and still developing.

Table 2. Panel Unit Root Tests

Variable	LLC Statistic	Prob. (LLC)	IPS Statistic	Prob. (IPS)
WME	-3.12	0.001	-2.98	0.002
PCI	-4.05	0.0	-3.87	0.0
ER	-2.75	0.003	-2.6	0.005
CAD	-2.62	0.004	-2.45	0.007
ETA	-3.01	0.001	-2.89	0.002
ROA	-3.45	0.0	-3.33	0.001
ROE	-3.5	0.0	-3.36	0.001
Tobin’s Q	-3.18	0.001	-3.05	0.002
FS	-2.9	0.002	-2.78	0.003

The results of the panel unit root tests reported in Table 2 show that all variables are stationary at the level, as indicated by significantly negative Levin–Lin–Chu (LLC) and Im–Pesaran–Shin (IPS) statistics with probabilities well below the 5 percent threshold. Waste management expenditure (WME) and pollution control investment (PCI) reject the null of a unit root, with LLC values of -3.12 ($p = 0.001$) and -4.05 ($p = 0.000$), respectively. Disclosure variables such as environmental reporting (ER) and carbon accounting disclosure (CAD) are also stationary, with IPS probabilities of 0.005 and 0.007, while environmental training and awareness (ETA) is confirmed stationary (LLC $p = 0.001$; IPS $p = 0.002$). Profitability measures (ROA, ROE, and Tobin’s Q) and the control variable, firm size (FS), also exhibit stationarity with p-values below 0.01. In all, Table 2 confirms that all variables are integrated of order zero, $I(0)$, making them appropriate for regression and cointegration analysis without differencing.

Table 3. Panel Cointegration Tests

Test	Value	Prob.
Panel v-Statistic	2.35	0.009
Panel rho-Statistic	-1.98	0.024
Panel PP-Statistic	-3.12	0.001
Panel ADF-Statistic	-3.45	0.0
Kao ADF t-Statistic	-3.21	0.001

The results of the Pedroni and Kao panel cointegration tests reported in Table 3 confirm the existence of a long-run equilibrium relationship among the variables. Four of the Pedroni statistics (panel v-statistic, panel rho-statistic, panel PP-statistic, and panel ADF-statistic) are significant at the 5 percent level or better, with probabilities of 0.009, 0.024, 0.001, and 0.000, respectively. Similarly, the Kao residual cointegration test supports this finding, yielding an ADF t-statistic of -3.21 ($p = 0.001$). Table 3 provides strong evidence that environmental responsibility measures (WME, PCI, ER, CAD, ETA), profitability indicators (ROA, ROE, Tobin's Q), and firm size (FS) move together in the long run, thereby justifying the use of panel regression techniques in subsequent analysis.

Table 4. Panel Regression Analysis (Fixed Effects)

Variable	Coefficient	Std. Error	t-Statistic	p-Value
WME	0.215	0.083	2.59	0.012
PCI	0.0031	0.001	3.1	0.003
ER	0.046	0.017	2.71	0.01
CAD	0.033	0.015	2.2	0.028
ETA	0.127	0.059	2.15	0.031
FS	0.081	0.019	4.26	0.001

R-squared = 0.66, F-stat = 19.32, Prob(F-stat) = 0.0

The fixed effects regression results in Table 4 indicate that the model is statistically significant ($F = 19.32$, $p < 0.01$) with an explanatory power of 66 percent ($R^2 = 0.66$), showing that environmental responsibility measures and firm size account for a substantial share of profitability variation. Waste management expenditure (WME) ($\beta = 0.215$, $p = 0.012$) and pollution control investment (PCI) ($\beta = 0.0031$, $p = 0.003$) significantly enhance financial performance. Similarly, environmental reporting (ER) ($\beta = 0.046$, $p = 0.010$) and carbon accounting disclosure (CAD) ($\beta = 0.033$, $p = 0.028$) exert positive effects, underscoring the role of transparency. Environmental training and awareness (ETA) ($\beta = 0.127$, $p = 0.031$) also contributes positively, while firm size (FS) ($\beta = 0.081$, $p = 0.001$) confirms that larger firms achieve higher profitability. Table 4 demonstrates that sustainability initiatives and firm size are significant drivers of profitability.

Table 5. Granger Causality Test

Null Hypothesis	F-Statistic	Probability
WME does not Granger-cause ROA	3.92	0.027
PCI does not Granger-cause ROA	4.18	0.021
ER does not Granger-cause ROA	2.98	0.043
ROA does not Granger-cause WME	1.25	0.296

The Granger causality results in Table 5 reveal a unidirectional relationship running from environmental responsibility measures to profitability. Waste management expenditure (WME) ($F = 3.92$, $p = 0.027$), pollution control investment (PCI) ($F = 4.18$, $p = 0.021$), and environmental reporting (ER) ($F = 2.98$, $p = 0.043$) all Granger-cause return on assets (ROA). However, the reverse effect, where profitability would Granger-cause WME, is not supported ($F = 1.25$, $p = 0.296$). These findings confirm that proactive environmental initiatives drive profitability rather than the other way around, underscoring the strategic role of sustainability in enhancing firm performance.

Table 6. Robustness Checks

Variable	ROE Coefficient	ROE p-Value	Tobin's Q Coefficient	Tobin's Q p-Value
WME	0.22	0.011	0.21	0.013
PCI	0.0032	0.002	0.003	0.003
ER	0.048	0.009	0.045	0.011
CAD	0.034	0.026	0.032	0.028
ETA	0.13	0.029	0.125	0.031
FS	0.082	0.001	0.081	0.001

The robustness tests reported in Table 6, which re-estimate the model using return on equity (ROE) and Tobin's Q as alternative profitability measures, yield results consistent with those obtained using ROA, confirming the reliability of the findings. Waste management expenditure (WME) remains positive and significant ($\beta = 0.22$, $p = 0.011$ for ROE; $\beta = 0.21$, $p = 0.013$ for Tobin's Q), as does pollution control investment (PCI) ($\beta = 0.0032$, $p = 0.002$; $\beta = 0.003$, $p = 0.003$). Disclosure practices—environmental reporting (ER) and carbon accounting disclosure (CAD)—also retain significant positive effects across both measures, while environmental training and awareness (ETA) continues to enhance performance. Firm size (FS) remains strongly significant, underscoring the scale advantages of larger firms. Table 6 demonstrates that the positive influence of environmental responsibility initiatives on profitability is robust across alternative indicators, thereby strengthening the validity of the study's conclusions.

Hypotheses Testing and Interpretation of Results

Evaluation of Hypothesis One (H1)

H1: Selected manufacturing firms in Nigeria do not significantly adopt environmental accounting practices.

Statistical Basis and Rationale

The evaluation of H1 is based on descriptive statistical evidence rather than inferential testing, as the hypothesis concerns the extent of adoption of environmental accounting practices rather than statistical relationships or causal inference. Descriptive analysis is therefore appropriate and consistent with prior environmental accounting studies that assess disclosure prevalence and investment patterns.

As reported in the descriptive statistics (Table 1), environmental accounting practices are visibly present across the sampled firms. Specifically, environmental reporting (ER) is disclosed by approximately 76 percent of the firms, while 57 percent provide carbon accounting disclosures (CAD). In addition, firms allocate an average of 4.6 percent of operating expenses to waste management and invest an average of ₦12.8 million annually in pollution control initiatives. Environmental training expenditures further indicate institutional commitment, averaging 3.3 percent of total training budgets.

These consistently high levels of disclosure and investment provide clear descriptive evidence that environmental accounting practices are actively adopted among the sampled firms. This pattern aligns with earlier Nigerian and emerging-market studies documenting increasing engagement with environmental reporting and sustainability investments among listed manufacturing firms.

Decision on H1

Based on this descriptive evidence, H1 is rejected. The findings indicate that selected Nigerian manufacturing firms meaningfully adopt environmental accounting practices, albeit with variation in intensity across firms.

Evaluation of Hypothesis Two (H2)

H2 was evaluated using Granger causality analysis, which examines whether past values of environmental accounting practices contain information useful for predicting future profitability. The results indicate a statistically significant unidirectional temporal relationship running from environmental accounting practices to profitability.

In contrast, the reverse relationship (profitability Granger-causing environmental practices) is statistically insignificant, suggesting that higher profitability does not systematically precede increased environmental investment within the sample period.

These results are consistent with prior studies in sustainability accounting that document predictive links from environmental practices to subsequent financial outcomes rather than contemporaneous or reverse causality.

Decision on H2

Based on this descriptive evidence, H1 is rejected. The findings indicate that selected Nigerian manufacturing firms meaningfully adopt environmental accounting practices, albeit with variation in intensity across firms.

Evaluation of Hypothesis Three (H3)

H3 was tested using panel regression analysis with firm fixed effects, controlling for firm size and unobserved heterogeneity. The regression results indicate that multiple environmental accounting proxies exhibit positive and statistically significant associations with profitability.

The model explains approximately 66 percent of the variation in profitability ($R^2 = 0.66$) and is statistically significant overall (F-statistic = 19.32, $p < 0.01$). Robustness checks using ROE and Tobin's Q yield consistent results, reinforcing the stability of the findings.

These results align closely with established empirical patterns in environmental accounting and sustainability literature, which document positive associations between environmental investments, disclosure quality, and firm financial performance across both developed and emerging economies.

Decision on H3

Based on the statistically significant regression results, H3 is rejected. The findings indicate that environmental accounting investments are associated with favourable financial outcomes rather than being purely compliance-driven expenditures.

Discussion of Findings

Waste Management Expenditure (WME)

The regression analysis revealed that WME has a positive and significant effect on profitability ($\beta = 0.215$, $p < 0.05$), with robustness checks across ROE and Tobin's Q confirming this relationship. Granger causality further shows that WME Granger-causes ROA ($p = 0.027$). This suggests that investment in waste management not only improves compliance but also enhances efficiency, reduces operational costs, and builds reputational capital. From the perspective of Stakeholder Theory, such investments meet societal expectations and strengthen legitimacy. The Resource-Based View (RBV) further explains this finding by positioning waste management practices as firm-specific resources that

can yield long-term competitive advantages. These results align with Obialor & Umeoduagu (2022), who reported that environmental practices in Nigeria improve long-term value creation.

Pollution Control Investment (PCI)

PCI exhibited a positive and significant influence on profitability ($\beta = 0.0031$, $p < 0.01$), with robustness checks confirming consistency across profitability measures. The Granger causality test also revealed that PCI Granger-causes ROA ($p = 0.021$), implying that investments in pollution control directly contribute to firm performance. Consistent with Stakeholder Theory, this demonstrates responsiveness to regulatory and community pressures, which builds stakeholder trust. Under the RBV, pollution control technologies and practices represent intangible assets that differentiate firms in competitive markets. This finding corroborates Clarkson et al. (2022), who established that proactive environmental investments enhance firm valuation.

Environmental Reporting (ER)

ER was found to significantly improve profitability ($\beta = 0.046$, $p < 0.05$), a relationship that remained robust across alternative profitability measures. Moreover, ER Granger-causes ROA ($p = 0.043$), suggesting that transparent disclosure practices precede financial improvements. This supports Stakeholder Theory, as reporting satisfies demands for accountability and reduces information asymmetry, while the RBV views disclosure as a source of reputational advantage. The result echoes Yusoff and Othman (2021), who demonstrated that sustainability reporting enhances market performance in Malaysia.

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Carbon Accounting Disclosure (CAD)

The regression results indicate that CAD positively influences profitability ($\beta = 0.033$, $p < 0.05$), with robustness checks confirming significance across ROE and Tobin's Q. This implies that firms

disclosing carbon emissions reduce reputational and regulatory risks, thereby gaining financial benefits. Under the RBV, carbon disclosure builds intangible resources such as market credibility and competitive differentiation. The finding is consistent with Iredele and Ofoegbu (2023), who showed that sustainability assurance and disclosure improve firm value in Nigeria.

Environmental Training and Awareness (ETA)

ETA positively and significantly impacts profitability ($\beta = 0.127$, $p < 0.05$), with robustness checks confirming the result across all profitability measures. This highlights the importance of employee capacity building in advancing sustainability strategies. From the RBV perspective, environmental knowledge and skills constitute firm-specific capabilities that are valuable, rare, and inimitable, providing a sustainable competitive advantage. In line with Stakeholder Theory, investment in staff training demonstrates commitment to long-term environmental responsibility, strengthening legitimacy. This finding supports Mans-Kemp and Van der Lugt (2022), who observed that environmental training enhances reporting quality and corporate performance.

Firm Size (FS)

Firm size was positively associated with profitability ($\beta = 0.081$, $p < 0.01$). Larger firms are more capable of absorbing environmental costs, implementing sophisticated environmental practices, and benefiting from economies of scale. Moreover, larger firms face higher stakeholder scrutiny, which motivates them to adopt robust environmental reporting and practices. This finding is consistent with Stakeholder Theory, as larger firms respond more directly to public expectations, and also with the RBV, as firm scale itself is a strategic resource. The result aligns with Appah and Bariweni (2022), who found that firm scale and governance strength mitigate earnings manipulation in Nigerian firms.

Taken together, the findings demonstrate that environmental accounting practices—whether expenditures, investments, disclosures, or training—contribute positively to firm profitability in Nigerian manufacturing firms. The results consistently support both Stakeholder Theory and the Resource-Based View, while reinforcing prior evidence from Nigeria and other emerging economies. This suggests that environmental responsibility is not only a compliance requirement but also a strategic pathway to long-term competitiveness and financial success.

Conclusion

This study examined the relationship between environmental accounting practices and profitability among selected Nigerian manufacturing firms using panel data spanning 2016–2024. By

combining panel regression techniques with cointegration and Granger causality analysis, the study provides evidence on how environmental accounting practices relate to firm performance over time. The empirical findings indicate that waste management expenditure, pollution control investment, environmental reporting, carbon accounting disclosure, and environmental training are consistently and positively associated with both accounting-based and market-based measures of profitability. The Granger causality results further suggest that past environmental accounting practices have predictive relevance for future profitability, while reverse predictability from profitability to environmental practices is not strongly supported.

Importantly, these findings do not imply definitive structural causation. Rather, they indicate the presence of robust temporal and predictive relationships between environmental accounting practices and firm profitability. This distinction is particularly relevant in the context of emerging economies such as Nigeria, where firm-level heterogeneity, regulatory dynamics, and data limitations may influence observed outcomes.

Overall, the study suggests that environmental accounting practices are systematically linked with favourable financial performance over time, supporting the view that sustainability-oriented accounting practices can coexist with corporate financial objectives. The study extends the environmental accounting literature by providing evidence from a developing-country context and by applying time-based analytical techniques that go beyond static association analysis.

Policy Recommendations

The findings of this study offer several policy-relevant insights for regulators, corporate managers, and other stakeholders, subject to appropriate caution regarding causal interpretation.

First, regulatory authorities such as the Nigerian Exchange Group (NGX) and the National Environmental Standards and Regulations Enforcement Agency (NESREA) may consider strengthening guidance on environmental accounting disclosures. Given the observed association between disclosure practices and firm performance, clearer reporting standards could improve transparency, comparability, and investor confidence without imposing undue reporting burdens.

Second, policymakers may explore incentive-based approaches—such as tax reliefs, disclosure recognition schemes, or access to green financing—to encourage voluntary adoption of environmental accounting practices. Such measures could support broader sustainability objectives while allowing firms flexibility in implementation.

Third, corporate managers may view environmental accounting practices as part of a broader strategic and risk-management framework rather than as purely compliance-driven activities. The observed temporal relationships suggest that sustained attention to environmental practices may align with longer-term financial performance and market valuation.

Finally, standard-setting bodies and professional accounting institutions may consider developing capacity-building initiatives and technical guidance to support consistent measurement and reporting of environmental accounting information. Improved data quality would enhance the reliability of future empirical research and support more rigorous evaluation of sustainability-related financial outcomes

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