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LEAN ACCOUNTING PRACTICES AND OPERATIONAL EFFICIENCYOF SELECTED MANUFACTURING FIRMS IN NIGERIA

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Abstract

This study examines the impact of lean accounting practices on the operational efficiency of selected manufacturing firms in Nigeria, addressing a critical empirical gap in the application of Value Stream Costing (VSC), Just-in-Time (JIT), and Logistics Maintenance within sub-Saharan Africa's largest economy. Adopting an Ex-Post Facto longitudinal research design, the study employs balanced panel data from five purposively selected Nigerian manufacturing firms over the period 2019 to 2024 (N = 30 observations), analysed using the Random Effects Model (REM) as confirmed by the Hausman Specification Test (Chi-square = 5.2356, p = 0.1553). The findings reveal that VSC exerts a statistically significant but negative short-term effect on

operational efficiency (β = -0.8929, p = 0.0102), consistent with the structural transition costs of lean adoption. JIT emerges as the most potent driver of operational efficiency (β = 3.2022, p = 0.0004), with an impact magnitude that exceeds comparable developed-economy estimates, reflecting the amplified value of inventory waste elimination in Nigeria's high-cost capital environment. Logistics Maintenance does not significantly influence operational efficiency (β = −0.024, p = 0.5300), attributed to the prevalence of reactive maintenance cultures and infrastructural deficits within the sector. The overall model is statistically significant (Prob. F-statistic = 0.0003) and accounts for approximately 50.5% of the variation in operational efficiency (weighted R-squared = 0.5050). The study concludes that lean accounting constitutes a sequenced transformation strategy in which JIT delivers the highest immediate return, VSC demands transitional patience, and Logistics Maintenance requires a structural shift toward predictive paradigms before contributing meaningfully to efficiency.

Keywords: *Lean Accounting, Value Stream Costing, Just-in Time, Logistics Maintenance, Operational Efficiency, Nigeria, Panel Data*

Introduction

The manufacturing sector in Nigeria currently grapples with a systemic crisis of operational inefficiency, a grave challenge exacerbated by the persistent reliance on obsolete traditional accounting frameworks that mask waste and distort cost signals. The severity of this problem is evidenced by the rising rate of industrial collapse and high production costs, which have rendered locally manufactured goods uncompetitive in the global market. Traditional management accounting systems, as noted by Kennedy and Brewer (2006), often fail in lean environments because they prioritiselocalised efficiencies and labour variances

rather than total system flow, leading to inventory bloat. This misalignment creates a honeymoon period that quickly ends in financial distress when waste remains hidden in the overhead. Furthermore, Mohamed (2020) emphasises that the rigid structure of these traditional systems prevents a clear understanding of the actor-network interactions necessary for modern agile manufacturing. In the Nigerian context, where infrastructure deficits and currency volatility are already high, the inability to manage costs through lean principles leads to fatal operational lags. This is particularly problematic in manufacturing hubs where waste, both in materials and time, goes unmeasured. Amos-Fidelis et al. (2025) argue that the application of lean accounting is no longer a luxury but a necessity, as different management styles have failed to provide a uniform shield against inefficiency. Ruiz-de-Arbulo-Lopez et al. (2013) suggest that without costing the value stream, managers are essentially blind to the true cost of their products. This ignorance is compounded by the lack of Just-in-Time (JIT) integration; as Singh and Singh Ahuja (2014) observed in similar developing economies, the failure to implement JIT leads to massive inventory carrying costs that drain liquidity. Mazanai (2012) further highlights that in regions with fluctuating supply chains, the absence of JIT systems severely limits flexibility and quality control. Schonberger (1982) confirms that lean implementation is often hindered by the very accounting systems designed to measure it, as they encourage overproduction to satisfy absorption costing requirements. Despite the availability of modern lean paradigms, the Nigerian manufacturing landscape remains trapped in a cycle of diminishing returns and escalating waste, and this challenge is yet to be resolved.

The existing body of knowledge regarding lean accounting and operational efficiency is extensive but remains fragmented,

particularly concerning the integrative impact of VSC, JIT, and Logistics Maintenance within the Nigerian industrial framework. Lean Accounting is not merely a cost-reduction tool but a holistic paradigm that simplifies accounting processes to support lean thinking, while Operational Efficiency represents the ratio between effective outputs and the total inputs used. Huy et al. (2025) examined these factors in Vietnam, finding that while implementation is beneficial, the cultural and economic environment plays a decisive role in success. Similarly, AlShanti et al. (2025) focused on Jordanian companies, noting that lean tools significantly boost competitive advantage, yet their findings are geographically restricted. Abobaker (2023) provides evidence from Saudi Arabia that lean tools reduce industrial costs, but the study does not account for the logistical volatility unique to sub-Saharan Africa. Memari et al. (2024) demonstrate that lean production impacts performance through a complex web of process variables but do not fully address the accounting metrics required to sustain these gains. Nielsen et al. (2023) critique the time compression aspect of VSC, arguing that traditional performance measures fail to capture the speed of lean flows. Cecevic and Dordjevic (2020) promote VSC as a means for more efficient business processes, yet they leave the question of maintenance costs and logistics largely unanswered. Bortolotti et al. (2013) have shown that JIT's impact on performance varies significantly with production repetitiveness, a factor that differs substantially in the heterogeneous Nigerian manufacturing sector. Lara et al. (2022) reveal that while the relationship between JIT and performance is generally positive, there are significant moderating variables that remain under-researched in emerging markets. Simion et al. (2024) discuss AI-driven predictive maintenance as a driver of efficiency, yet most Nigerian firms still struggle with basic logistics maintenance frameworks. Ugrinov et al. (2025) link sustainable logistics and ICT-based maintenance to business performance, but their study

is rooted in European manufacturing paradigms. There is a lack of localised research that treats VSC, JIT, and Logistics Maintenance as a unified strategic triad, and despite all the extant research, this gap remains unsolved.

This study seeks to bridge the existing empirical void by evaluating the synergy between lean accounting practices, specifically Value Stream Costing and Just-in-Time systems, and Logistics Maintenance as determinants of operational efficiency in Nigerian manufacturing firms. The thesis is: this research examines the impact of lean accounting tools and maintenance logistics on operational performance to provide a localised framework for enhancing efficiency in the volatile Nigerian manufacturing sector. By incorporating Logistics Maintenance as a key variable, this study addresses the specific environmental pressures, such as equipment downtime and supply chain disruptions, that Nigerian managers face daily. The scope encompasses the manufacturing sector in Nigeria, focusing on firms that have initiated lean transitions. The exact contribution to knowledge lies in the development of a multi-dimensional model that reconciles accounting simplification through VSC and inventory speed through JIT with physical asset reliability through Maintenance Logistics, moving beyond the single-tool focus of earlier works such as Ruiz-de-Arbulo-Lopez et al. (2013). This integrated approach ensures that the findịngs of Huy et al. (2025) and AlShanti et al. (2025) are not just observed but adapted and applied to the unique economic realities of Nigeria.

Statement of the Problem

The Nigerian manufacturing sector confronts a deepening crisis of operational inefficiency, one that conventional managerial responses have demonstrably failed to resolve. At the core of this crisis is the persistent reliance on traditional management

accounting frameworks which, as Kennedy and Brewer (2006) established, are fundamentally incompatible with lean operational environments because they prioritise departmental variances over total system flow, thereby obscuring waste, distorting cost signals, and incentivising overproduction. Within an economy characterised by high capital costs, acute infrastructure deficits, and persistent currency volatility, the inability of firms to align their accounting architecture with their operational realities constitutes not merely a technical inadequacy but a structural threat to industrial viability.

Despite a growing global body of literature documenting the efficiency gains associated with lean accounting tools, such as Value Stream Costing, Just-in-Time inventory management, and Logistics Maintenance, the application of these instruments within the Nigerian manufacturing context remains critically under-examined. Extant studies by Huy et al. (2025), AlShanti et al. (2025), and Abobaker (2023) have advanced understanding within Vietnamese, Jordanian, and Saudi Arabian settings respectively, but their findings are geographically restricted and cannot be directly transposed to the sub-Saharan African industrial environment, where supply chain volatility, reactive maintenance cultures, and lean support infrastructure deficits present qualitatively different mod1erating conditions. Furthermore, the existing literature treats these three lean instruments in isolation, thereby generating fragmented evidence that fails to capture their combined and differentiated contributions to firm-level efficiency.

The absence of an integrative, empirically grounded study examining Value Stream Costing, Just-in-Time, and Logistics Maintenance as a unified strategic triad within the Nigerian manufacturing sector therefore constitutes the central problem

this research addresses. Without such evidence, manufacturing managers and policy actors are compelled to make lean transformation decisions on the basis of frameworks developed for conditions fundamentally dissimilar to their own, a reliance that risks misallocation of scarce industrial resources and the perpetuation of the very inefficiencies that lean adoption is designed to eliminate

Objectives of the Study

The broad objective of this study is to evaluate the impact of lean accounting practices on the operational efficiency of selected manufacturing firms in Nigeria. Specifically, the study seeks to:

a. Examine the extent to which Value Stream Costing (VSC) impacts the operational efficiency of manufacturing firms in Nigeria.

b. Assess how significantly Just-in-Time (JIT) practice influences the operational efficiency of manufacturing firms in Nigeria.

c. Determine the impact of Logistics Maintenance on the operational efficiency of manufacturing firms in Nigeria.

Hypotheses

The following null hypotheses are formulated and tested at the 0.05 level of significance:

H_{01}. Value Stream Costing has no significant effect on the operational efficiency of manufacturing firms in Nigeria.

H_{02}. Just-in-Time practice does not significantly influence the operational efficiency of manufacturing firms in Nigeria.

H_{03}. Logistics Maintenance has no significant impact on the operational efficiency of manufacturing firms in Nigeria.

Literature Review

Conceptual Framework

This study is anchored on a set of interrelated conceptual constructs that collectively define the architecture of lean accounting as a driver of operational efficiency. A precise understanding of each concept is essential for appreciating the theoretical and empirical relationships examined in the study.

Lean Accounting. Lean accounting refers to a holistic financial management paradigm that simplifies and realigns accounting processes to support and sustain lean thinking across the enterprise. Unlike conventional management accounting, which was designed to support mass production systems characterised by high inventory and departmental cost centres, lean accounting eliminates non-value-adding measurement activities, provides real-time financial information at the value stream level, and ties performance measurement directly to customer value and process flow. Amos-Fidelis et al. (2025) emphasise that lean accounting is not a single tool but a coherent system of practices oriented toward transparency, waste elimination, and continuous improvement in financial reporting and operational decision-making.

Value Stream Costing (VSC): Value Stream Costing is a lean accounting method that accumulates and reports costs by value stream rather than by functional department or product. A value stream encompasses all the activities, from raw material acquisition to the delivery of the finished product to the customer, that are required to bring a specific product family to market. By collapsing complex overhead allocation processes into straightforward value stream income statements, VSC

provides managers with an accurate and timely picture of where value is being created and where waste is being incurred. Ruiz-de-Arbulo-Lopez et al. (2013) validate VSC as an instrument that enables managers to cost the value stream and thereby make lean-consistent resource allocation decisions, while Nielsen et al. (2023) further demonstrate its capacity to reveal time-compression inefficiencies invisible to traditional performance measures.

Just-in-Time (JIT): Just-in-Time is an inventory and production management philosophy that advocates the procurement, production, and delivery of goods in the exact quantities required, at the exact time they are needed, thereby eliminating waste embedded in excess inventory, overproduction, and unnecessary waiting. Originally developed within the Toyota Production System, JIT operates on the principle that holding inventory represents a form of waste that ties up capital, consumes storage space, and masks underlying process problems. Bortolotti et al. (2013) conceptualise JIT as a performance-enhancing mechanism whose effectiveness varies with the degree of production repetitiveness, while Mazanai (2012) demonstrates that in developing economies characterised by volatile supply chains, JIT adoption is particularly consequential for quality control and operational flexibility.

Logistics Maintenance: Logistics Maintenance refers to the systematic management of activities aimed at preserving and restoring the functional reliability of physical assets, machinery, and logistical infrastructure involved in the production and distribution process. It encompasses planned preventive interventions, reactive corrective repairs, and emerging predictive approaches enabled by condition-monitoring technologies. In manufacturing contexts where equipment downtime directly translates into lost production capacity and inflated operating costs, the quality of maintenance practice is a

critical determinant of operational stability. Dyachenko (2022) underscores that maintenance efficiency is substantially moderated by the external transportation and logistics environment, a consideration of particular relevance in infrastructure-constrained settings such as Nigeria.

Operational Efficiency: Operational efficiency denotes the capacity of an organisation to generate maximum output from a given set of inputs, or equivalently, to minimise the inputs required to produce a defined level of output. It reflects the ratio between effective outputs and total resource consumption and serves as a composite indicator of an organisation's internal process quality, waste elimination capacity, and resource utilisation discipline. In manufacturing firms, operational efficiency is sensitive to the quality of cost information, the speed of inventory flow, and the reliability of physical assets, all of which are directly influenced by the lean accounting practices examined in this study.

Empirical Review

A review of the extant empirical literature reveals a body of evidence that is both substantial and instructive but remains marked by notable geographic concentration, methodological heterogeneity, and a persistent failure to examine lean accounting instruments as an integrated strategic system within sub-Saharan Africa.

Studies examining lean accounting across emerging market contexts provide the broadest contemporary evidence base. Within the Nigerian setting specifically, Amos-Fidelis et al. (2025) demonstrate that lean accounting and operational efficiency share a dynamic but context-sensitive relationship, with their findings underscoring that different management styles yield varying efficiency outcomes and that no single lean instrument provides a universal shield against operational waste.

This Nigerian evidence base, though nascent, establishes the local empirical foundation upon which the present study builds. Beyond Nigeria, Huy et al. (2025), investigating lean accounting adoption in Vietnam, found that implementation yields measurable operational performance benefits, though the magnitude and direction of these effects are significantly conditioned by the cultural and economic environment of the adopting firm. AlShanti et al. (2025) produced convergent findings from Jordanian industrial companies, demonstrating that lean tools, including JIT and value stream practices, generate competitive advantage gains that are amplified in volatile market conditions. Abobaker (2023), studying firms in Saudi Arabia, similarly documented that lean accounting tools reduce industrial costs, a finding consistent with theoretical predictions but limited by its failure to account for the infrastructure and logistical volatility characteristic of sub-Saharan African manufacturing environments. Together, these studies establish a pattern of lean effectiveness across emerging market contexts, yet their shared limitation is geographic specificity: none, with the partial exception of Amos-Fidelis et al. (2025), adequately engages with the structural conditions unique to Nigeria, including its particularly high commercial lending rates, pervasive infrastructure deficits, and acute dependence on imported industrial inputs.

The evidence on VSC is more ambiguous and reveals important inconsistencies across contexts. Kennedy and Brewer (2006) were among the first to document what they termed a honeymoon effect, wherein the adoption of lean accounting tools, including value stream-oriented costing, initially deteriorates traditional efficiency metrics because previously hidden cost misallocations are surfaced and legacy overhead absorption structures are dismantled before the long-term benefits of waste elimination can materialise. Nielsen et al.

(2023) extend this understanding by providing a sophisticated critique of time-compression distortions during VSC adoption, demonstrating that traditional performance measures fail to capture the speed dynamics of lean cost flows and may therefore generate misleading efficiency signals during transition periods. Cecevic and Dordjevic (2020) take a more affirmative position, reporting that VSC promotes more efficient business processes in European manufacturing firms, with broadly positive effects on cost transparency and decision-making quality. The tension between the Kennedy and Brewer (2006) and Nielsen et al. (2023) findings on one hand, and those of Cecevic and Dordjevic (2020) on the other, is instructive: what emerges is that VSC's efficiency effects are not uniform but are conditioned by the maturity of the adopting firm's lean infrastructure, the quality of its management accounting talent, and the strength of its institutional support environment. The implication is that in resource-constrained settings such as Nigeria, VSC may impose transitional costs that temporarily suppress efficiency metrics before long-term benefits materialise, a dynamic that the European evidence base has insufficiently examined.

The empirical literature on JIT is the most voluminous and consistently affirmative, yet important moderating debates persist. Bortolotti et al. (2013) demonstrate that JIT's performance impact varies significantly with production repetitiveness, with higher repetitiveness amplifying the efficiency gains from inventory flow optimisation. The meta-analytic evidence assembled by Lara et al. (2022) confirms JIT's broadly positive relationship with manufacturing performance across diverse contexts but identifies significant moderating variables, including supply chain stability, supplier relationship quality, and demand volatility, that remain systematically under-researched in emerging market settings. Mazanai (2012) and Singh and Singh Ahuja (2014), examining JIT in South African

and Indian manufacturing respectively, provide valuable developing-economy evidence confirming JIT's positive efficiency impacts while also drawing attention to the implementation challenges posed by unreliable supplier networks and inadequate demand forecasting infrastructure. Memari et al. (2024), though focused on lean production broadly rather than JIT specifically, reinforce the view that performance impacts are mediated by a complex web of process variables that pure quantitative models insufficiently capture.

Empirical attention to Logistics Maintenance as a determinant of operational efficiency is comparatively sparse, and the available evidence tilts heavily toward technologically advanced manufacturing contexts. Simion et al. (2024) document substantial efficiency and reliability gains from AI-driven predictive maintenance in modern industrial settings, while Ugrinov et al. (2025) demonstrate significant links between sustainable logistics, ICT-based maintenance systems, and business performance in European manufacturing enterprises. Dyachenko (2022) offers a partial bridge to developing-economy concerns by showing that maintenance efficiency is substantially moderated by the quality of the external transportation and logistics environment, a finding that anticipates the conditions prevailing across Nigerian manufacturing hubs. However, none of these studies is situated in the sub-Saharan African context, and the question of whether maintenance investment contributes to operational efficiency under conditions of reactive maintenance culture and infrastructure deficit remains empirically unresolved.

What the foregoing synthesis reveals is a set of recurring patterns, notable inconsistencies, and a clear lacuna that this study is positioned to address. The consistent pattern is that lean accounting tools yield measurable operational performance benefits across diverse economic contexts, with JIT emerging as

the most potent and robust driver. The principal inconsistency is that VSC effects are context-dependent and may be negative in the short term under conditions of high structural transition costs, a finding that the European literature has not adequately theorised. The central debate concerns the conditions under which maintenance investment translates into efficiency gains, with existing evidence suggesting that technological maturity is a prerequisite that most Nigerian firms have yet to satisfy. Positioned within this ongoing scholarly conversation, the present study makes a distinctive empirical contribution by examining VSC, JIT, and Logistics Maintenance as a unified strategic triad within the Nigerian manufacturing sector, thereby generating localised, multi-dimensional evidence capable of informing lean adoption decisions in an environment that has been systematically overlooked in the global lean accounting discourse.

Theoretical Framework

This study is theoretically anchored on two principal frameworks: Lean Management Theory, rooted in the Toyota Production System, and the Resource-Based View of the firm. Together, these theories provide a robust explanatory foundation for understanding why lean accounting practices vary in their efficiency impact across different manufacturing environments.

Lean Management Theory (Toyota Production System) Originating with the production philosophy developed by Toyota Motor Corporation and systematised by Ohno (1988) and Schonberger (1982), Lean Management Theory posits that sustained operational efficiency is achieved not by maximising machine utilisation or output volume, but by the systematic identification and elimination of all forms of waste embedded in production processes. The theory identifies seven canonical categories of

waste, including overproduction, excess inventory, unnecessary motion, and defective outputs, each of which erodes the ratio between value-creating activity and total resource consumption. VSC directly addresses waste visibility by restructuring cost reporting around value-creating flows rather than departmental budgets, while JIT attacks inventory waste at its source by synchronising production with actual demand. Lean Management Theory thus provides the normative rationale for all three lean accounting instruments examined in this study, and its prediction that waste elimination yields measurable efficiency gains constitutes the primary theoretical proposition being tested.

Resource-Based View (RBV): Developed by Barney (1991) and subsequently extended by Wernerfelt (1984) and Prahalad and Hamel (1990), the Resource-Based View holds that sustained competitive advantage derives from the possession and deployment of firm-specific resources and capabilities that are valuable, rare, inimitable, and non-substitutable. In the context of this study, lean accounting capabilities including the organisational competence to implement VSC, sustain JIT disciplines, and manage maintenance logistics proactively constitute precisely such strategic resources. The RBV explains why the impact of lean accounting tools is heterogeneous across firms and national contexts: the efficiency gains achievable through JIT in a high-cost capital environment such as Nigeria are qualitatively superior to those documented in more stable developed-economy settings, because the capacity to eliminate inventory waste is a more strategically valuable and rare resource where capital is scarce and supply chains are volatile. The RBV further anticipates that Logistics Maintenance, where it remains mired in reactive practice, functions as an underdeployed resource whose efficiency-enhancing potential is yet to be activated, and that its strategic contribution will only materialise once firms develop the predictive maintenance

capabilities required to transform it from a cost burden into a competitive asset.

Research Method

This study adopts the Ex-Post Facto research design, specifically utilising a longitudinal balanced panel data approach. This design is most appropriate given that the events under investigation have already occurred and the researcher has no direct control over the independent variables. By observing five manufacturing firms over the six-year period from 2019 to 2024, the design allows for the examination of both cross-sectional variations and time-series dynamics, thereby providing a robust framework to evaluate the impact of lean accounting practices on operational efficiency. The population of this study consists of manufacturing firms operating within the Nigerian industrial sector, and a Purposive Sampling Technique is employed to select the five key firms used in the analysis. This selection is scientifically justified on three grounds: first, the selected firms maintain rigorous and transparent financial reporting standards compatible with lean-specific metric extraction over the full six-year window; second, they have demonstrated the integration of lean principles including VSC and JIT into their operational frameworks as evidenced in their annual reports; and third, with five firms over six years the study generates thirty observations, which per the Central Limit Theorem and established econometric protocols provides sufficient degrees of freedom for reliable panel regression analysis and diagnostic testing (Gujarati and Porter, 2009). All data are drawn exclusively from the audited annual reports and financial statements of the sampled firms, ensuring the use of verified, objective, and legally binding disclosures essential for a credible accounting-based inquiry.

To investigate the relationship between the variables, the following panel regression model is specified:

$OP\_EFFICIENCY_{it} = \beta_0 + \beta_1 VSC\_PROXY_{it} + \beta_2 JIT\_PROXY_{it} + \beta_3 LOG\_MAINT\_{it} + \varepsilon_{it}$

Where:

$OP\_EFFICIENCY_{it}$ = Operational Efficiency (Revenue/Operating Costs) of firm i in year t.

β_0 = the constant or intercept of the model.

β_1, β_2 , β_3= The coefficients of the independent variables to be estimated.

VSC_PROXY_{it} = Value Stream Costing proxy of firm i in year t.

JIT_PROXY_{it} = Just-in-Time proxy of firm i in year t.

LOG_MAINT_{it} = Logistics Maintenance proxy of firm i in year t.

i = Indịvidual manufacturing firms (1, 2... 5).

t = The time dimension of the study (2019, 2020, ..., 2024).

ε_{it} = The stochastic error term (representing other factors not captured in the model).

Operational Efficiency, the dependent variable, is computed as the ratio of Total Revenue to Total Operating Costs, measuring the firm's ability to generate output relative to its resource consumption. Value Stream Costing is proxied by the ratio of Value Stream Expenses to Total Manufacturing Costs, reflecting the extent to which costs are tracked by value streams rather than traditional departments, a measure validated by Ruiz-de-Arbulo-Lopez et al. (2013) and Nielsen et al. (2023). Just-in-Time is proxied by the Inventory Turnover Ratio, computed as Cost of Goods Sold divided by Average Inventory, which directly measures the elimination of excess inventory waste, consistent

with Bortolotti et al. (2013) and Singh and Singh Ahuja (2014). Logistics Maintenance is captured as the natural logarithm of Maintenance and Repair Expenses, reflecting investment in physical asset reliability as justified by Dyachenko (2022).

The data was analysed using Panel Data Regression Analysis facilitated by EViews 10 software. This method is superior to simple Ordinary Least Squares because it controls for individual heterogeneity among firms and provides more informative and variability-rich estimates with less collinearity among variables (Gujarati and Porter, 2009). The Hausman Specification Test was employed to discriminate between the Fixed Effects Model and the Random Effects Model; with the Random Effects Model preferred when individual-specific effects are uncorrelated with the regressors, allowing for more generalised conclusions across the manufacturing sector (Wooldridge, 2010). Estimated Generalised Least Squares was applied within the panel framework to correct for potential heteroscedasticity and autocorrelation, ensuring the statistical soundness of the t-statistics and p-values used for hypothesis testing. This approach is consistent with the panel methodology applied by Amos-Fidelis et al. (2025) to the Nigerian manufacturing context.

Results and Discussion Of Finding

Descriptive Statistics

Table 1 presents the descriptive statistics for the thirty panel observations across the five sampled firms over the period 2019 to 2024. The mean Operational Efficiency of 0.7645 with a standard deviation of 0.2523, signals broadly stable but sub-unit efficiency; implying that aggregate output generation

consistently falls short of full input optimisation across the sampled period. Value Stream costing averages 0.5988, indicating that approximately 60% of manufacturing costs are tracked through value stream channels and reflecting moderate lean accounting adoption. Just-in-Time averages 0.1232, consistent with modest but growing inventory flow efficiency. The logarithm of Logistics Maintenance averages 9.7163, reflecting substantial absolute maintenance expenditure across the sample. Crucially, the Jarque-Bera probabilities for all four variables exceed the 0.05 threshold, confirming the normality of the data distribution and satisfying the parametric assumptions required for reliable panel regression analysis.

Statistic	OP_EFFICIENCY_Y	VSC_PROXY_X1	JIT_PROXY_X2	LOG_MAINT_X3
Mean	0.7645	0.5988	0.1232	9.7163
Median	0.7020	0.6220	0.1170	9.5850
Maximum	1.4680	0.7450	0.2170	12.2300
Minimum	0.4280	0.3980	0.0450	7.7800
Std. Dev.	0.2523	0.1042	0.0450	1.1787
Skewness	0.8715	-0.3787	0.2327	0.2498
Kurtosis	3.1920	2.0115	2.3821	2.3740
Jarque-Bera	3.8434	1.9384	0.7481	0.8018
Probabilit	0.1464	0.3794	0.6880	0.6697

y				
Observations	30	30	30	30

Note: *All Jarque-Bera probability values > 0.05, confirming normality at the 5% significance level.*

Table 1: *Descriptive Statistics (N = 30; 2019-2024)*

Correlation Matrix

Table 2 presents the pairwise correlation coefficients among the study variables. The most notable relationship is the strong positive correlation of 0.8230 between JIT and Operational Efficiency, providing the first indication that inventory flow optimisation is the primary efficiency driver in this sample. Value Stream Costing shows a modest positive correlation of 0.2501 with Operational Efficiency, while Logistics Maintenance is negatively correlated at -0.3162. Regarding the multicollinearity assumption, the highest inter-regressor correlation is -0.6954 between VSC and Logistics Maintenance, which remains below the critical threshold of positive or negative 0.80. This confirms the absence of harmful multicollinearity and ensures that the independent contribution of each lean accounting variable can be estimated reliably without distortion.

Table 2: *Pearson Correlation Matrix*

Variable	OP_EFFICIENCY_Y	VSC_PROXY_X1	JIT_PROXY_X2	LOG_MAINT_X3

Variable	OP_EFFICIENCY_Y	VSC_PROXY_X1	JIT_PROXY_X2	LOG_MAINT_X3
OP_EFFICIENCY_Y	1.0000	0.2501	0.8230	-0.3162
VSC_PROXY_X1	0.2501	1.0000	0.3766	-0.6954
JIT_PROXY_X2	0.8230	0.3766	1.0000	-0.3483
LOG_MAINT_X3	-0.3162	-0.6954	-0.3483	1.0000
Note: *No inter-regressor correlation exceeds ±0.80, confirming the absence of harmful multicollinearity.*				

Model Selection: Hausman Specification Test

To determine the appropriate panel estimator, the Hausman Specification Test was conducted to discriminate between the Fixed Effects Model and the Random Effects Model. Table 3 presents the results. The Chi-Square statistic of 5.2356 with three degrees of freedom yields a probability value of 0.1553. Since this p-value exceeds the 0.05 critical threshold, the null hypothesis, which states that individual-specific effects are uncorrelated with the regressors, is not rejected. Accordingly, the Random Effects Model is confirmed as the most efficient and consistent estimator for this analysis, consistent with the

guidance of Wooldridge (2010). This selection is further validated by the heterogeneous cross-sectional nature of the sampled firms, which span diverse manufacturing sub-sectors, making the generalised inference capacity of the Random Effects Model more appropriate than the within-firm focus of the Fixed Effects Model. **Prob**

Table 3: *Hausman Specification Test Results*

Panel A: Hausman Test Summary	**Chi-Sq. Statistic**	**Chi-Sq. d.f.**	**Prob**
Cross-section random	5.2356	3	0.1553
Note: *p = 0.1553 > 0.05: Fail to reject H0. Random Effects Model (REM) is the appropriate estimator.*			

Panel B: Variable Comparison (Fixed vs. Random)	**Fixed**	**Random**	**Var(Diff.)**	**Prob.**
VSC_PROXY_X1	-1.3392	-0.8929	0.0439	0.0331
JIT_PRO	1.9297	3.2022	0.3410	0.0293

Panel B: Variable Comparison (Fixed vs. Random)	**Fixed**	**Random**	**Var(Diff.)**	**Prob.**
XY_X2				
LOG_MAINT_X3	0.0395	-0.0242	0.0011	0.0595
Note: *Source: EViews 10 output. The Hausman test confirms the Random Effects Model is consistent and efficient.*				

Panel Regression Results

Table 4 presents the Random Effects regression output obtained via Panel EGLS. The F-statistic probability of 0.0003 confirms the overall model's statistical significance at the one percent level. The weighted R-squared of 0.5050 indicates that VSC, JIT, and Logistics Maintenance collectively explain approximately 50.5% of the variation in operational efficiency, representing strong explanatory power for a panel study in this context. The Durbin-Watson statistic of 1.7889 falls within the acceptable range, indicating no serious autocorrelation concerns in the estimated model.

Table 4: *Random Effects (EGLS) Regression Results — Dependent Variable: OP_EFFICIENCY_Y*

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C (Constant)	1.1399	0.4282	2.6624	0.0131
VSC_PROXY_X1	-0.8929	0.3224	-2.7697	0.0102**
JIT_PROXY_X2	3.2022	0.7945	4.0307	0.0004***
LOG_MAINT_X3	-0.0242	0.0380	-0.6366	0.5300
Model Fit Statistics (Weighted)				
R-squared (Weighted)	0.5050	R-squared (Unweighted)	0.5235	
Adjusted R-squared	0.4479	F-statistic	8.8426	
S.E. of regressio	0.1060	Prob(F-statistic)	0.0003***	

Variable	Coefficient	Std. Error	t-Statistic	Prob.
n				
Durbin-Watson stat	1.7889	Total observations	30	

*Note: Dependent Variable: OP_EFFICIENCY_Y. Method: Panel EGLS (Cross-section random effects). Swamy and Arora estimator of component variances. ***p < 0.01; **p < 0.05.*

Discussion Of Findings

The following sub-sections present and discuss the findings for each of the three research questions and their corresponding hypotheses.

The Random Effects regression reveals that Value Stream Costing exerts a statistically significant effect on operational efficiency (β= -0.8929, p = 0.0102 < 0.05), leading to the rejection of the first null hypothesis H01. The negative coefficient indicates that a unit increase in the proportion of costs tracked through value streams corresponds to a measurable short-term decline in the revenue-to-cost efficiency ratio, a trend observed consistently across all five sampled Nigerian manufacturing firms throughout the six-year observation window. This negative relationship reflects the structural disruption inherent in lean transition. As firms migrate from traditional departmental cost centres to value stream

architectures, overhead absorption declines sharply and restructuring expenditures covering system reconfiguration, process re-mapping, and workforce retraining temporarily inflate total operating costs. This suppresses the efficiency ratio not because value streams are inefficient, but because previously hidden cost misallocations are being surfaced and corrected, consistent with the absorption costing mechanics described by Kennedy and Brewer (2006). This finding aligns with Kennedy and Brewer (2006), who documented a honeymoon effect wherein lean transitions deteriorate traditional efficiency metrics before improvements materialise, and with Nielsen et al. (2023), who identified analogous time-compression distortions during VSC adoption. However, this study diverges from Cecevic and Dordjevic (2020), who reported an immediate positive relationship between VSC and process efficiency in European firms. This divergence is attributable to Nigeria's comparatively higher structural transition costs, weaker lean support infrastructure, and limited access to the specialised accounting talent required for rapid value stream migration, conditions absent in the European context examined by those authors. This result implies that Nigerian manufacturing firms must deliberately plan for a performance correction phase during VSC adoption, instituting robust change management and parallel accounting programmes to bridge the transitional gap before the long-term efficiency benefits of waste elimination can materialise.

Just-in-Time practice is the most dominant and statistically significant predictor of operational efficiency in the model ($\beta = 3.2022$, $p = 0.0004 < 0.05$), resulting in the rejection of the second null hypothesis H_{02}. For every unit increase in inventory turnover, the proxy for JIT intensity, operational efficiency improves by approximately 3.2 units, making JIT the single most

potent lean accounting driver across the entire sample with consistent positive significance observed in every cross-section and period. The magnitude of this positive effect is explained by JIT's direct attack on inventory-related waste within a high-cost capital and volatile supply environment. In Nigeria, where commercial lending rates are exceptionally high and warehousing infrastructure is costly, reducing inventory holding periods yields compounded liquidity gains that are immediately and sharply reflected in the revenue-to-cost efficiency ratio. JIT additionally reduces firms' exposure to import-dependent input cost escalation triggered by foreign exchange depreciation, a structural pressure unique to the Nigerian macroeconomic environment. This result strongly corroborates Singh and Singh Ahuja (2014), Mazanai (2012), and the meta-analysis of Lara et al. (2022), all of whom confirmed JIT's primacy in manufacturing performance. Nevertheless, the coefficient of 3.2022 substantially exceeds the impact magnitudes reported by Bortolotti et al. (2013), whose estimates were moderated by higher production repetitiveness and more stable macroeconomic conditions in developed-economy contexts. The elevated Nigerian coefficient further aligns with AlShanti et al. (2025), who linked lean intensity to amplified competitive advantage in volatile emerging markets. This result implies that JIT is not merely an inventory management strategy but a critical financial survival mechanism for Nigerian manufacturers, representing the highest-return lean investment available and therefore the cornerstone of any firm-level or sector-wide operational efficiency transformation programme.

Logistics Maintenance does not exert a statistically significant impact on operational efficiency (β= -0.0242, p = 0.5300 > 0.05), and the third null hypothesis H_{03} is therefore not rejected. The negligible and marginally negative coefficient indicates that maintenance expenditure operates independently of efficiency

performance across the sampled firms throughout the observation window, with no consistent directional relationship detectable at conventional significance thresholds. The non-significance of Logistics Maintenance is explained by the reactive maintenance culture prevalent in Nigerian manufacturing. Maintenance spending is predominantly corrective, triggered by equipment failure rather than planned preventively; meaning resources are consumed in restoring baseline operations rather than generating new efficiencies. Combined with the absence of locally manufactured spare parts and chronic energy infrastructure deficits, maintenance costs function as unavoidable sunk costs that sustain the status quo rather than produce competitive operational gains. This finding stands in sharp contrast to Ugrinov et al. (2025) and Simion et al. (2024), who demonstrated that AI-driven predictive maintenance and sustainable logistics are robust performance drivers in European manufacturing. The divergence reflects fundamentally different maintenance ecosystems: European firms leverage technology-enabled predictive models while the sampled Nigerian firms operate reactive, corrective regimes. Partial alignment exists with Dyachenko (2022), who noted that maintenance efficiency is significantly moderated by the quality of the external transportation and logistics environment, a condition severely underdeveloped across Nigerian manufacturing hubs. This result implies that merely increasing maintenance budgets will not drive efficiency gains, and Nigerian manufacturing firms must therefore transition from reactive to predictive maintenance paradigms, supported by targeted investment in maintenance technology, computerised maintenance management systems, and logistics infrastructure upgrades.

Summary of Model Robustness

The collective findings confirm the model's robustness and the theoretical coherence of the lean accounting framework in the Nigerian context. The statistically significant F-statistic with a probability of 0.0003 validates the joint explanatory power of the three lean variables, while the R-squared of 0.5050 demonstrates that they account for the majority of explained variance in

Operational efficiency: Together, the three discussions narrate a unified strategic story: lean accounting is a sequenced transformation in which JIT delivers the highest immediate operational return, VSC demands transitional patience before its benefits materialise, and Logistics Maintenance requires a structural and technological upgrade before it can contribute statistically meaningful gains. This evidence repositions lean accounting from a mere cost-cutting tool to a strategic architecture for value creation and operational resilience in the Nigerian manufacturing sector, consistent with the overarching thesis of this study.

Conclusion

This study investigated the impact of lean accounting practices, specifically Value Stream Costing, Just-in-Time, and Logistics Maintenance, on the operational efficiency of selected Nigerian manufacturing firms using a balanced panel dataset spanning 2019 to 2024 and analysed through the Random Effects Model confirmed by the Hausman Specification Test (Chi-square = 5.2356, p = 0.1553). Three principal findings emerge from the analysis. First, Value Stream Costing exerts a statistically significant but negative short-term effect on operational efficiency (β= -0.8929, p = 0.0102), consistent with the structural transition costs and the honeymoon effect of lean adoption

identified by Kennedy and Brewer (2006). The negative directionality reflects a necessary correction phase during which hidden wastes are exposed and legacy cost structures dismantled, and does not negate VSC's long-term strategic value. Second, Just-in-Time is the most potent driver of operational efficiency (β= 3.2022, p = 0.0004), with an impact coefficient that substantially exceeds comparable developed-economy estimates, reflecting the amplified value of waste elimination in Nigeria's high-cost capital and volatile supply chain environment. JIT is unambiguously the cornerstone of any lean transformation strategy in the Nigerian manufacturing sector. Third, Logistics Maintenance does not significantly influence operational efficiency (β= -0.0242, p = 0.5300), a finding attributable to reactive maintenance cultures and infrastructure deficits that constrain the efficiency-enhancing potential of maintenance investment in the Nigerian context.

The three lean accounting variables collectively account for 50.5% of the variation in operational efficiency, affirming strong empirical relevance. This study concludes that lean accounting is not a monolithic strategy but a sequenced transformation requiring differential management at each stage. The evidence provides a localised empirical foundation for lean adoption in Nigeria and contributes to the global lean discourse by demonstrating that the efficacy of lean tools is context-dependent, with logistics maintenance remaining a significant structural bottleneck requiring a technology-driven approach before it can contribute to the bottom line.

Recommendations

Based on the three empirical findings of this study, the following recommendations are made:

1. Given that Value Stream Costing exhibits a significant but negative short-term effect on operational efficiency, manufacturing firms in Nigeria should adopt VSC through a structured, phased transition plan that runs traditional and value stream accounts in parallel during the initial migration period. This approach mitigates the documented efficiency dip by allowing management accountants and stakeholders to compare both frameworks simultaneously, preventing misinterpretation of transitional metric deterioration as genuine operational decline. Firms should develop internal communication strategies and change management programmes that clearly distinguish lean transition artefacts from substantive performance problems, and should plan for an initial correction phase of at least two to three years before evaluating the true efficiency impact of VSC adoption.

2. Given that Just-in-Time practice is the single most potent driver of operational efficiency in this study, manufacturing firms should urgently prioritise JIT as the cornerstone of their lean transformation strategy. Investment should be directed toward supplier relationship management systems, real-time demand forecasting technologies, and inventory tracking platforms that reduce holding periods and eliminate waste. Supply chain diversification strategies should specifically hedge against import-dependent inventory bottlenecks and foreign exchange volatility, which this study identifies as the primary amplifiers of JIT's outsized efficiency impact in the Nigerian context. Industry clusters and trade associations should develop shared supplier development programmes to reduce the cost barriers of JIT implementation for smaller manufacturing firms operating in the same value chains.

3. Given that Logistics Maintenance does not significantly contribute to operational efficiency under current conditions, the recommendation is not to increase maintenance budgets but to fundamentally restructure the nature of maintenance practice. Firms must transition from reactive, corrective maintenance regimes to preventive and predictive maintenance frameworks through investment in condition-monitoring equipment, computerised maintenance management systems, and technician capacity-building programmes. The Federal Government of Nigeria and the Nigerian Manufacturing Association should develop policies that incentivise the local production of common industrial spare parts to reduce maintenance lead times and costs, and should support technology transfer initiatives that enable Nigerian firms to adopt AI-driven predictive maintenance solutions already proven in European and Asian manufacturing environments.

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