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IMPACT OF LEAN AND AGILE WORKFORCE STRATEGIES ON OPERATIONAL EFFICIENCY IN NIGERIAN MANUFACTURING FIRMS

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Abstract

This study examined the impact of Lean and Agile workforce strategies on operational efficiency in Nigerian manufacturing firms, with particular emphasis on the moderating role of employee empowerment and workforce skills. The objectives were to assess the individual and joint effects of Lean and Agile workforce strategies on operational efficiency and to determine how employee empowerment and skills influence these relationships. The study adopted a descriptive cross-sectional survey design. Data were collected from 482 valid respondents drawn from selected manufacturing firms in Lagos and Ogun States using a structured questionnaire. Descriptive statistics, correlation analysis, and hierarchical regression techniques were employed for data analysis using SPSS. The findings revealed that Agile workforce strategies ($\beta = 0.412$, $p < 0.05$) and Lean workforce strategies ($\beta = 0.385$, $p < 0.05$) significantly improved operational efficiency. Employee empowerment and workforce skills also significantly strengthened the relationship between workforce strategies and operational efficiency. The study recommends increased investment in employee training, empowerment initiatives, multiskilling programmes, and decentralized decision-making structures to enhance organizational responsiveness and efficiency.

Keywords: *Agile Workforce Strategies, Employee Empowerment, Lean Workforce Strategies, Nigerian Manufacturing Firms, Operational Efficiency.*

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1. INTRODUCTION

Global manufacturing is increasingly shaped by volatility, technological advancement, and rapidly changing customer demands (Ohno, 1988; Womack & Jones, 2003). In response, Lean and Agile workforce strategies have emerged as critical operational frameworks for improving efficiency, flexibility, responsiveness, and competitiveness (Naylor et al., 1999; Christopher & Towill, 2001).

Despite increased adoption of operational excellence frameworks globally, contextual barriers in emerging economies such as Nigeria may alter expected outcomes, necessitating localized empirical validation. Nigeria's manufacturing sector continues to face significant infrastructure deficiencies, unstable power supply, logistics constraints, policy inconsistencies, and workforce capability gaps, all of which may limit the effectiveness of Lean and Agile implementation (World Bank, 2020; National Bureau of Statistics, 2023).

While several studies have established positive relationships between Lean and Agile practices and organizational performance in developed economies, there remains limited empirical evidence on how these strategies jointly influence operational efficiency within Nigeria's unique business environment. In many Nigerian manufacturing firms, Lean tools are often implemented without corresponding investment in workforce development, employee empowerment, and adaptive organizational capabilities. This creates a critical gap between theoretical expectations and operational realities.

Furthermore, Nigeria presents a distinctive context because manufacturing firms must simultaneously pursue efficiency, flexibility, and survival under resource-constrained and institutionally challenging conditions. Workforce capability therefore becomes central to the successful implementation of Lean and Agile systems (Becker, 1964; Jesuthasan & Boudreau, 2022).

This study therefore examines the combined effect of Agile and Lean workforce strategies on operational efficiency in the Nigerian manufacturing sector, with particular attention to workforce capability, employee empowerment, and contextual implementation challenges.

1.1 Statement of the Problem

Despite the growing adoption of Lean and Agile practices in the manufacturing sector, operational efficiency in Nigeria remains relatively low. The sector continues to underperform in terms of productivity, cost efficiency, and global competitiveness, largely due to infrastructural deficiencies, institutional constraints, and workforce-related challenges (World Bank, 2021; National Bureau of Statistics, 2023). While Lean strategies are designed to eliminate waste and improve efficiency, their effectiveness is often undermined by external disruptions such as unreliable power supply, poor transportation networks, and inefficient logistics systems. Similarly, Agile strategies, which emphasize flexibility and responsiveness, require a highly skilled and adaptable workforce, an area where significant gaps still exist in Nigeria (Anyanwu, 2020; UNDP & Federal Government of Nigeria, 2021).

A major issue lies in the misalignment between workforce capabilities and operational strategies. Many firms implement Lean tools without corresponding investments in employee skills, empowerment, training, and participation, thereby limiting the realization of expected efficiency gains (Akingbade, 2014). At the same time, attempts to improve flexibility through Agile practices may introduce additional complexity, coordination challenges, and operational costs, especially within resource-constrained environments. This creates a persistent tension between efficiency and adaptability that is not sufficiently understood within the Nigerian manufacturing context (Qamar & Hall, 2018).

Furthermore, existing empirical studies largely examine Lean and Agile strategies in isolation, with limited attention given to their integrated application within developing economies. Existing evidence remains inconclusive regarding whether Lean and Agile strategies independently or jointly improve operational efficiency in developing manufacturing contexts. While some studies report positive effects on productivity and performance, others suggest that contextual barriers such as inadequate infrastructure, institutional weaknesses, cultural dynamics, and workforce limitations may reduce or distort expected outcomes. These mixed findings reveal an important empirical gap that requires further investigation. This gap is particularly significant in Nigeria, where manufacturing firms operate under severe structural and institutional constraints that may alter the effectiveness of operational excellence frameworks. Despite increasing global acceptance of Lean and Agile approaches, there remains insufficient context-specific empirical evidence on how their combined application influences operational efficiency in the Nigerian manufacturing sector.

Therefore, the core problem addressed by this study is the lack of localized empirical evidence on how integrated Agile and Lean workforce strategies affect operational efficiency in Nigeria's manufacturing sector, particularly under conditions characterized by infrastructural deficiencies, workforce capability gaps, and institutional constraints.

1.2 Research Questions

1. How do agile workforce capabilities (flexibility and responsiveness) influence operational efficiency in Nigerian manufacturing firms?

2. To what extent do lean workforce practices (continuous improvement culture and waste reduction) influence operational efficiency in Nigerian manufacturing firms?

3. Does employee empowerment and workforce skill levels moderate the relationship between agile and lean workforce strategies and operational efficiency in Nigerian manufacturing firms?

4. What is the combined effect of agile and lean workforce strategies on operational efficiency in Nigerian manufacturing firms?

1.3 Research Objectives

1. To evaluate the extent to which agile workforce capabilities (flexibility and responsiveness) influence operational efficiencies of manufacturing firms in Nigeria

2. To evaluate the extent to which lean workforce practices (continuous improvement culture and waste reduction) influence operational efficiency in Nigerian manufacturing firms.

3. To examine the moderating effect of employee empowerment and workforce skill levels on the relationship between agile, lean workforce strategies and operational efficiency

4. To examine the combined effect of agile and lean workforce strategies on operational efficiency in Nigerian manufacturing firms.

1.4 Research Hypothesis

H_{01}: Agile workforce capabilities (flexibility and responsiveness) have no significant influence on operational efficiency in Nigerian manufacturing firms.

H_{02}: Lean workforce practices (continuous improvement and waste reduction) have no significant influence on operational efficiency in Nigerian manufacturing firms.

H_{03}: Employee empowerment and workforce skill levels do not significantly moderate the relationship between Lean/Agile workforce strategies and operational efficiency.

H_{04}: Agile and lean workforce strategies have no significant joint effect on operational efficiency in Nigerian manufacturing firms.

2. LITERATURE REVIEW

2.1 Conceptual Review

2.1.1 The Concept of Lean and Agile Workforce Strategies

Contemporary manufacturing environments are increasingly shaped by volatility, technological disruption, and fluctuating customer demand, reducing the effectiveness of rigid production systems and increasing the need for adaptive operational models. Within this context, Lean and Agile workforce strategies have emerged as complementary approaches for balancing efficiency and responsiveness (Naylor et al., 1999; Christopher & Towill, 2001).

Lean workforce strategy focuses on waste reduction, continuous improvement, process standardization, and operational stability (Ohno, 1988; Womack & Jones, 2003). However, evidence suggests that Lean effectiveness depends less on technical tools and more on workforce capability, employee participation, and organizational learning (Liker, 2020). Agile workforce strategy, in contrast, emphasizes flexibility, responsiveness, and rapid adaptation under changing conditions (Goldman et al., 1995). Its effectiveness is strongly linked to workforce empowerment, multiskilling, and decentralized decision-making (Franco & Landini, 2022).

The integration of Lean and Agile ("Leagile") strategies reflects the need to reconcile efficiency with adaptability. Lean enhances process discipline and cost efficiency, while Agile strengthens responsiveness and operational flexibility. Their combined effect therefore creates a dual capability system in which operational efficiency depends on both process optimization and workforce adaptability (Naylor et al., 1999). From a Dynamic Capabilities perspective, Lean and Agile strategies function as mechanisms for resource reconfiguration under uncertainty (Teece et al., 1997). However, their effectiveness remains context-dependent,

particularly in developing economies characterized by infrastructural instability, institutional weaknesses, and workforce capability constraints.

2.1.2 Workforce Flexibility and Responsiveness

Workforce flexibility and responsiveness constitute the core dimensions of Agile workforce strategy, but they influence operational efficiency through different mechanisms. Flexibility reflects the capacity to adapt to changing operational demands, while responsiveness captures the speed and effectiveness of that adaptation (Bernardes & Hanna, 2009). Operational efficiency therefore depends not merely on adaptability, but on the ability to rapidly convert flexibility into coordinated action.

From a Dynamic Capabilities perspective, firms sustain performance by continuously reconfiguring resources under changing conditions (Teece et al., 2016). Functional flexibility through multiskilling and cross-functional competence improves operational continuity and resilience, whereas excessive reliance on numerical flexibility may weaken organizational learning and knowledge retention (Atkinson, 1984; Kalleberg, 2018).

Empirical evidence further shows that flexibility alone does not guarantee efficiency. Weak coordination systems, delayed decision-making, and inadequate workforce capability can reduce the performance benefits of Agile systems (Swafford et al., 2008; Dubey et al., 2020). In Nigeria's volatile manufacturing environment, operational efficiency increasingly depends on workforce adaptability, decentralized decision-making, and rapid responsiveness (Ogunnaike et al., 2022). However, where empowerment and workforce skills remain weak, Agile practices may increase operational complexity rather than improve efficiency (Tortorella et al., 2020).

2.1.3 Continuous Improvement and Waste Reduction

Continuous improvement and waste reduction are central dimensions of Lean workforce strategy, based on the assumption that operational efficiency improves when non-value-adding activities are minimized, and organizational learning becomes continuous. Kaizen emphasizes incremental improvement through daily problem-solving and process learning rather than isolated innovation initiatives (Imai, 1986; Deming, 1986). However, evidence suggests that Lean effectiveness depends less on technical tools and more on employee involvement, leadership support, and organizational culture (Netland & Ferdows, 2016).

Waste reduction improves operational efficiency by minimizing defects, delays, excess inventory, and underutilized resources (Ohno, 1988). Yet, its implementation remains context-dependent. In volatile environments such as Nigeria, infrastructural instability and supply disruptions often require operational buffers that conflict with traditional Lean assumptions (Oyelaran-Oyeyinka & Lal, 2020).

This creates a tension between efficiency optimization and operational resilience. While inventory minimization enhances process flow under stable conditions, buffering mechanisms may improve continuity under uncertainty (Naim et al., 2023). Consequently, Lean effectiveness depends on the workforce's capability to balance efficiency with adaptability under changing operational conditions.

2.1.4 Employee Empowerment and Workforce Skills

Employee empowerment and workforce skills function as moderating variables that influence the extent to which Lean–Agile workforce strategies improve operational efficiency. This implies that operational systems alone may not generate sustainable efficiency gains without adequate workforce capability.

Employee empowerment reflects the degree of autonomy, participation, and decision-making authority within organizational systems (Bowen & Lawler, 1992). Lean and Agile systems depend on decentralized coordination, continuous improvement, and rapid problem-solving, making workforce participation essential. However, empowerment improves operational performance only when supported by competence, information access, digital capability, and organizational support structures (Tortorella et al., 2017; Jesuthasan & Boudreau, 2022).

Workforce skills represent the technical and adaptive competencies required for effective Lean–Agile implementation. Evidence shows that multiskilling, continuous learning, and workforce adaptability improve productivity, flexibility, and operational continuity (Muduli, 2016; Jesuthasan & Boudreau, 2022). From a Dynamic Capabilities perspective, empowerment and skills function as complementary capabilities enabling effective resource reconfiguration under uncertainty (Teece et al., 1997). Consequently, workforce capability moderates how effectively Lean and Agile strategies translate into operational efficiency outcomes.

2.1.5 Operational Efficiency in the Nigerian Manufacturing Industry

Operational efficiency represents the dependent variable in this study and extends beyond traditional cost minimization to include productivity, quality, delivery reliability, and operational continuity under volatile conditions (Modig & Åhlström, 2012). Within Lean–Agile systems, efficiency emerges through the interaction of process discipline, workforce adaptability, and operational responsiveness.

Lean strategies enhance efficiency through waste reduction and process standardization, while Agile systems improve continuity and responsiveness under uncertainty. However, the Nigerian manufacturing environment is constrained by infrastructural instability, energy disruptions, weak logistics systems, and institutional uncertainty, all of which reduce operational predictability (Akinwale & Olusanya, 2021; World Bank, 2023).

Recent studies argue that firms in volatile environments increasingly prioritize resilience alongside efficiency, often maintaining operational buffers despite higher costs (Ivanov, 2022; Naim et al., 2023). This creates a structural tension between Lean efficiency and adaptive resilience. Consequently, operational efficiency in Nigeria is better understood as a context-dependent outcome shaped by Lean workforce strategies, Agile workforce strategies, and workforce capability under conditions of uncertainty.

2.2. Theoretical Review

2.2.1 Dynamic Capabilities Theory (DCT)

Dynamic Capabilities Theory (DCT), developed by David Teece, Gary Pisano, and Amy Shuen (1997), explains how firms sustain performance by integrating and reconfiguring resources in response to environmental change. Unlike RBV, which emphasizes resource possession, DCT focuses on adaptability, making it particularly relevant in volatile manufacturing contexts.

DCT is operationalized through three interrelated processes: sensing, seizing, and transforming (Teece, 2007). Sensing involves identifying operational disruptions and emerging opportunities, often through frontline workforce awareness and responsiveness. Seizing refers to mobilizing resources through rapid decision-making, continuous improvement systems, and waste reduction practices embedded in Lean operations (Liker, 2020). Transforming involves

the continuous reconfiguration of processes, skills, and organizational routines, requiring workforce flexibility and multi-skilling.

Within the Nigerian manufacturing environment, these capabilities are critical due to infrastructural instability, exchange rate volatility, and supply chain disruptions. Firms capable of reconfiguring production inputs, sourcing systems, and operational processes demonstrate greater resilience and continuity under uncertainty (Adeleye et al., 2020). However, organizational rigidity and centralized management structures may weaken responsiveness and delay capability deployment (Oghojafor et al., 2012).

DCT provides a direct explanation for operational efficiency outcomes. Sensing capabilities improve production continuity through early identification of disruptions. Seizing capabilities reduces cycle time through faster operational decisions and continuous improvement practices. Transforming capabilities enhance product quality through ongoing skill development and process adaptation. Thus, operational efficiency is viewed not as a static outcome but as a function of continuous capability renewal.

Despite its relevance, DCT faces criticism regarding measurement because dynamic capabilities are often inferred from performance outcomes rather than directly observed (Ambrosini & Bowman, 2009). In developing economies, infrastructural deficits, weak institutional support, and limited finance further constrain capability development (Adeyeye et al., 2016; Anyanwu, 2020). To address this limitation, the present study operationalizes dynamic capabilities through measurable workforce attributes such as flexibility, responsiveness, and empowerment, and links them directly to operational efficiency indicators.

2.2.2 Human Capital Theory (HCT)

Human Capital Theory (HCT), developed by Gary Becker (1964), explains productivity differences through investments in employee education, training, and skill development. The theory argues that employees possess knowledge and competencies that function as economic assets capable of improving organizational performance.

Applied to manufacturing, HCT suggests that workforce training, technical competence, and continuous learning enhance operational efficiency by improving productivity, reducing errors, and supporting process innovation. Lean and Agile systems particularly depend on skilled employees capable of adapting to operational changes, solving production problems, and

implementing continuous improvement initiatives. In the Nigerian context, where skill shortages and technical gaps remain major industrial constraints, investment in workforce development becomes essential for sustaining efficiency and organizational adaptability (Anyanwu, 2020).

However, HCT has been criticized for assuming that skill acquisition automatically translates into productivity gains without sufficiently accounting for organizational and environmental constraints. In practice, employee capability may remain underutilized where firms lack empowering structures, technological support, or adaptive management systems. Consequently, this study integrates HCT with RBV and DCT to provide a broader explanation of how workforce capability, organizational systems, and dynamic adaptation collectively influence operational efficiency in Nigerian manufacturing firms.

2.3. Empirical Review

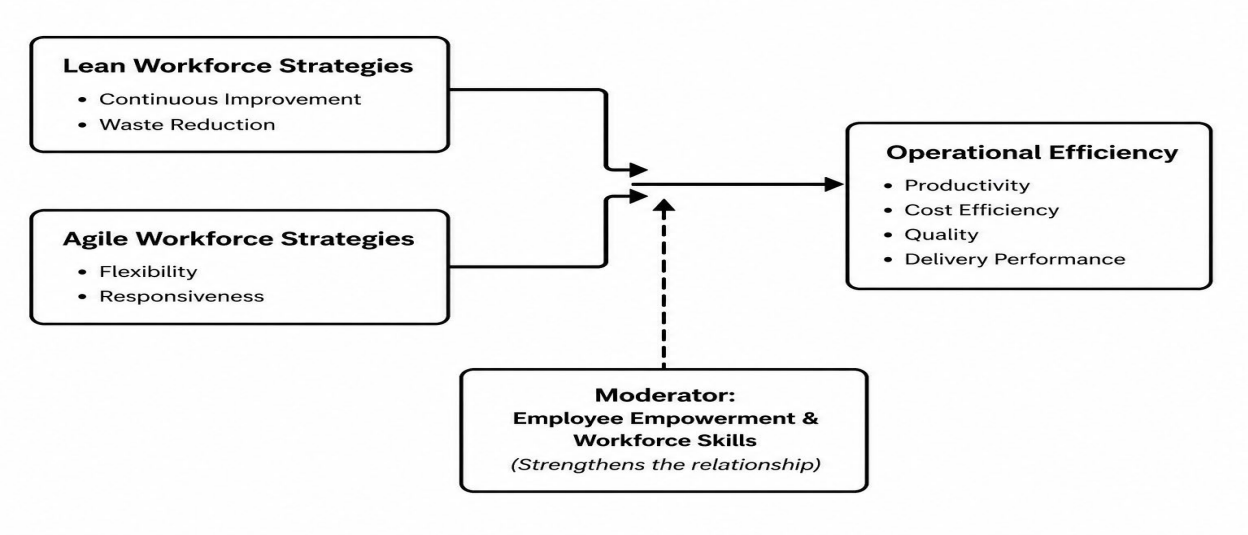
Empirical evidence suggests that operational strategies improve performance only when supported by workforce capability and enabling organizational systems. While prior studies confirm positive effects of Lean practices, quality management, technological capability, and human capital individually, few studies examine their integrated influence on operational efficiency within developing manufacturing contexts.

Studies on Lean implementation in Nigeria report improvements in waste reduction, workflow efficiency, and quality performance, but outcomes are strongly moderated by employee involvement, training, organizational learning, and management support (Amos et al., 2018; Nwibere, 2022). Similarly, research on Total Quality Management and technological capability shows that performance gains depend largely on workforce competence and continuous employee development (Adeyeye et al., 2016; Akinwale et al., 2020).

Human capital constraints remain a critical limitation within Nigeria's manufacturing sector. Evidence shows that technical skill gaps, inadequate training investment, and weak organizational support systems reduce productivity and limit the effectiveness of advanced operational systems (Sulaiman et al., 2015; Anyanwu, 2020). Organizational culture further shapes outcomes, as hierarchical structures and high-power distance weaken employee participation, responsiveness, and innovation (Oghojafor et al., 2012).

Overall, the literature indicates that Lean and Agile systems do not independently guarantee operational efficiency. Their effectiveness is contingent on workforce capability, employee empowerment, organizational learning, and contextual conditions. However, existing evidence remains fragmented and largely examines these variables separately rather than as integrated operational capabilities. Consequently, limited empirical attention has been given to how Lean and Agile workforce strategies jointly influence operational efficiency within the Nigerian manufacturing context.

2.4 Conceptual Framework



The conceptual framework illustrates the relationship between Lean and Agile workforce strategies and operational efficiency in Nigerian manufacturing firms. It further shows that employee empowerment and workforce skills moderate the strength of this relationship by enhancing the effectiveness of workforce strategies.

3. METHODOLOGY

This study adopts a descriptive cross-sectional survey design to examine the relationship between Lean and Agile workforce strategies and operational efficiency in Nigerian manufacturing firms. The design supports quantitative analysis of variables at a single point in time without experimental manipulation (Creswell, 2014). The population comprises production, supervisory, quality control, and management employees from selected manufacturing firms in Lagos and Ogun States, selected because they are Nigeria's major industrial hubs with high concentrations of formally registered manufacturing firms. Selected

firms possess structured production systems and a minimum of five years of operational experience to ensure relevance and consistency.

A stratified random sampling technique is employed to ensure proportional representation across employee categories (Saunders et al., 2019). The population is divided into production and management strata, after which random sampling is applied within each group. The sample size is determined using Yamane's (1967) formula: n=1+N(e)2N

where:

n = sample size,

N = population size, and

e = level of precision (sampling error), usually set at 0.05 or 5%.

At a 5% margin of error, the formula produces a target sample size of 500 respondents, with an additional 15–20% distributed to account for non-response bias. The sample is proportionally allocated as 70% production staff, 20% supervisory staff, and 10% senior management staff.

Primary data are collected through a structured questionnaire adapted from validated prior studies on Lean systems, workforce agility, empowerment, and operational efficiency (Liker, 2020; Jesuthasan & Boudreau, 2022). Responses are measured using a five-point Likert scale ranging from "Strongly Disagree" to "Strongly Agree."

To ensure measurement quality, both validity and reliability procedures are employed. Content validity is established through expert review by specialists in operations management and organizational studies, while construct validity is ensured through alignment between measurement items and study variables. Reliability is assessed through a pilot study using Cronbach's Alpha coefficient, with a threshold value of 0.70 considered acceptable for internal consistency (Cronbach, 1951).

Data analysis is conducted using SPSS. Descriptive statistics are used to summarize respondent characteristics and variable distributions, while correlation analysis examines relationships among variables. Multiple and hierarchical regression analyses are further employed to test the

predictive and moderating effects of Lean workforce strategies, Agile workforce strategies, and employee empowerment on operational efficiency (Hair et al., 2019).

The regression model is specified as:

$$OE = \beta_0 + \beta_1 AG + \beta_2 LN + \beta_3 EMP + \epsilon$$

Where:

(OE) = Operational Efficiency, (AG) = Agile Workforce Strategies, (LN) = Lean Workforce Strategies, (EMP) = Employee Empowerment and Workforce Skills, (β_0) = Constant term, (β_1–β_3) = Regression coefficients, (ϵ) = Error term.

Ethical standards, including informed consent, confidentiality, voluntary participation, and respondent anonymity, are strictly maintained throughout the study.

4. DATA ANALYSIS AND INTERPRETATION

4.1 Response Rate

Description	Frequency	Percentage
Questionnaires Distributed	500	100%
Valid Responses	482	96.4%
Invalid/Excluded	18	3.6%

Interpretation: The response rate of 96.4% is considered adequate and statistically reliable for quantitative analysis.

4.2 Reliability and Diagnostic Tests

Reliability Test (Cronbach's Alpha)

Variable	Cronbach Alpha	Interpretation
Agile Workforce Strategies	0.84	Reliable
Lean Workforce Strategies	0.87	Reliable
Employee Empowerment & Skills	0.81	Reliable
Operational Efficiency	0.85	Reliable

Interpretation: All variables recorded Cronbach Alpha values above the acceptable threshold of 0.70, confirming internal consistency and reliability of the measurement scale.

Regression Assumption Tests

Diagnostic Test	Value	Interpretation
VIF Range	1.42 – 2.11	No multicollinearity
Durbin-Watson	1.89	No autocorrelation
Normality Test	Acceptable	Residuals normally distributed
Heteroskedasticity Test	Not Significant	Homoscedasticity satisfied

Interpretation: Diagnostic results confirm that the regression assumptions of normality, independence, multicollinearity, and homoscedasticity were satisfied, validating the suitability of the regression model.

4.3 Descriptive Statistics

Variable	Mean	Interpretation
Agile Workforce Strategies	4.12	High adoption
Lean Workforce Strategies	4.35	Very high adoption
Operational Efficiency	4.08	High performance level

Interpretation: Lean practices recorded slightly higher adoption levels than Agile strategies, while overall operational efficiency remained positively rated.

4.4 Test of Hypothesis One (H_{01})

Agile Strategies → Operational Efficiency

Variable	Beta (β)	t-value	p-value	Decision
Agile Strategies	0.412	7.31	0.000	Reject H_{01}

R	R^2	Adjusted R^2
0.642	0.412	0.408

Interpretation: Agile workforce strategies significantly improve operational efficiency, explaining 41.2% of the variation in performance outcomes.

4.5 Test of Hypothesis Two (H_{02})

Lean Strategies → Operational Efficiency

Variable	Beta (β)	t-value	p-value	Decision
Lean Strategies	0.385	6.99	0.000	Reject H_{02}

R	R^2	Adjusted R^2
0.621	0.385	0.381

Interpretation: Lean workforce strategies significantly influence operational efficiency, accounting for 38.5% of observed performance variation.

4.6 Test of Hypothesis Three (H_{03})

Moderating Effect of Employee Empowerment and Skills

Model	R^2	ΔR^2	p-value
Base Model (Lean + Agile)	0.472	—	—
With Moderator	0.622	0.150	0.000

Variable	Beta (β)	t-value	p-value
Empowerment × Skills	0.350	7.14	0.000

Decision: Reject H_{03}

Interpretation: Employee empowerment and workforce skills significantly strengthen the relationship between Lean–Agile workforce strategies and operational efficiency.

4.7 Test of Hypothesis Four (H_{04})

Combined Effect of Lean and Agile Strategies

Variable	Beta (β)	p-value
Agile Strategies	0.298	0.000
Lean Strategies	0.271	0.000

R^2	Interpretation
0.472	Joint explanatory power

Decision: Reject H_{04}

Interpretation: Lean and Agile workforce strategies jointly exert significant positive effects on operational efficiency.

4.8 Summary of Hypotheses

Hypothesis	Decision
H_{01}	Rejected
H_{02}	Rejected
H_{03}	Rejected
H_{04}	Rejected

Overall Interpretation.

The findings confirm that Lean and Agile workforce strategies significantly improve operational efficiency both independently and jointly. The results further demonstrate that

employee empowerment and workforce skills strengthen these relationships, reinforcing the importance of workforce capability as a moderating factor within operational excellence systems.

4.2 Discussion of Findings

The findings strongly support Dynamic Capabilities Theory, which explains how firms sustain performance through resource adaptation under changing conditions (Teece et al., 1997; Teece, 2007). The significant effect of Agile workforce strategies indicates that flexibility and responsiveness improve operational efficiency in volatile manufacturing environments. This supports Ogunnaike et al. (2022), although it contrasts with studies suggesting that flexibility may increase operational complexity where workforce capability is weak (Tortorella et al., 2020).

Similarly, the positive influence of Lean workforce strategies reinforces the importance of continuous improvement and waste reduction in enhancing operational performance. The findings support Amos et al. (2018) and Nwibere (2022), who reported positive effects of Lean systems on workflow efficiency and quality performance. However, the present study further shows that Lean effectiveness depends on workforce and contextual conditions rather than tool adoption alone.

The significant moderating effect of employee empowerment and workforce skills also strengthens Human Capital Theory (Becker, 1964). The findings indicate that workforce capability enhances the effectiveness of Lean and Agile systems, supporting Dauda and Akingbade (2011) and Adeyeye et al. (2016), who emphasized the role of skilled and engaged employees in achieving operational performance. However, persistent skill gaps and limited training opportunities in Nigeria continue to constrain the full realization of Lean–Agile benefits (Ohiomah & Aigbavboa, 2016; Anyanwu, 2020).

Overall, the findings demonstrate that operational efficiency is driven not by isolated Lean or Agile tools, but by the integration of operational strategies with workforce capability. The significant moderation effect further confirms human capital as a critical enabler of sustained operational performance in Nigerian manufacturing firms.

5. CONCLUSION, RECOMMENDATIONS, AND SUGGESTIONS FOR FURTHER STUDIES

5.1 Conclusion

The study shows that operational efficiency in Nigerian manufacturing firms emerges from the interaction of Lean and Agile capabilities within a Leagile workforce system, rather than from either approach in isolation. Efficiency gains depend on how well these capabilities are jointly deployed under changing environmental conditions.

From a Dynamic Capabilities perspective, performance is driven less by the adoption of Lean or Agile tools and more by firms' ability to sense changes, reconfigure resources, and align workforce systems accordingly (Teece et al., 1997; Teece, 2007). This highlights capability deployment as the key mechanism of value creation.

The findings further indicate that human capital especially employee empowerment and skill levels conditions the effectiveness of these strategies. Thus, workforce quality determines the extent to which Lean and Agile practices translate into operational gains.

Overall, operational efficiency is best understood as an outcome of alignment between organisational strategy and workforce capability rather than isolated process improvements (Dauda & Akingbade, 2011).

5.2 Recommendations

Firms should prioritise human capital development as a strategic driver of efficiency by investing in training, multiskilling, and employee empowerment.

Organisational structures should be decentralised to enhance responsiveness and enable effective implementation of Agile practices, particularly in unstable operating environments.

At the policy level, strengthening technical and vocational education is critical to closing skill gaps and improving manufacturing sector capability absorption.

5.3 Suggestions for Further Studies

Future studies should adopt longitudinal designs to examine how Lean and Agile capabilities evolve over time. Comparative research across manufacturing sub-sectors is needed to assess contextual differences in effectiveness.

Further work should also explore how organisational learning and leadership influence the conversion of workforce capability into sustained performance.

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