Exploring the Adoption of Lean Manufacturing and Its Influence on Operational Performance: A Case Study of Dangote Cement Factory

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ABSTRACT

Lean manufacturing has transformed from being more than just a production philosophy advocated by Toyota to an international approach to efficiency, waste reduction and competitiveness. Although lean practices have been organized in developed economies like Japan, the United States, and the United Kingdom, their use in developing economies has not been widely addressed, especially in the context of the manufacturing industry in Nigeria. The current study examined the impact of lean manufacturing on the operational performance of Dangote Cement Factory, which is one of the largest industrial companies in Nigeria. Quantitative research design was adopted whereby the survey strategy was adopted whereby structured questionnaires were administered to the operational staff. Based on the estimated sample size, 94% of the responses were obtained and analyzed using IBM SPSS and the PROCESS macro.

Results obtained showed that lean practices, such as Kaizen, Standard Operating Procedures, Value Stream Mapping, and Total Productive Maintenance, have a positive influence on productivity, efficiency, and quality. The regression analysis revealed that operational efficiency is significantly predicted by lean adoption (beta = 0.602, R2= 362, $p < 0.001$) and values that show a significant relationship between lean practices and operational efficiency, while the moderation analysis showed that Lean Training and Management Support is a good moderator for the adoption of lean practices on operational efficiency. There were, however, obstacles like a lack of adequate training, expensive implementation, and a lack of management support that prevented complete usage. The paper concludes that lean manufacturing increases the performance of operations, but the continuous use of lean manufacturing in Nigeria lies on the commitment of the leadership, training of the staff, and the infrastructural preparedness.

Keywords: Lean Manufacturing, Operational Performance, Kaizen, Value Stream Mapping, Total Productive Maintenance

INTRODUCTION

Nigeria's manufacturing sector continues to face challenges related to high operational costs, inefficiencies, and waste (Moneme, 2016). Consequently, according to Okolocha & Anugwu (2022), to maintain competitiveness and protect profit margin, organizations must adopt practices of production that can have a profound impact on the performance of firms. Lean manufacturing, a philosophy designed to maximize productivity through waste elimination, has been widely applied in developed economies sectors (Henao et al., 2019; Okolocha & Anugwu, 2022; Alshammari et al., 2025).

However, its impact on operational performance in Nigerian firms remains underexplored (Olu-Lawal et al 2024). Empirical evidence from developed economies shows that, with the lean principle implementation, there is reduction in costs and an increase in competitiveness; there are so many such research findings from developing countries that confirm the same effects in countries like the United States, China, and Japan (Olu-Lawal et al., 2024). Although rudimentary lean practices have been found in sectors such as the garment industry in Nigeria, there are often obstacles that Nigeria businesses face in fully implementing core lean methodologies (Bamisaye et al 2023). This gap highlights the need for a context specific research work on lean adoption,

efficacy and the organizational enablers required to support the sustaining of the significant performance improvements in the Nigerian manufacturing sector. The proposed study hence aims at evaluating the degree of lean manufacturing adoption and its impact on operation performance within the Nigeria manufacturing industry through a case study of one of the most leading cement manufacturing firm in Nigeria, Dangote Cement. The research also seeks to determine the different lean methods applied, and the obstacle experienced by the workers in the manufacturing industry to the achievement of good lean manufacturing practices.

Problem statement

Since the early 1990s, big firms have utilized lean manufacturing to enhance production efficiency and cost reductions, as well as to gain a competitive edge (Jones, 2013). The impacts of the Lean manufacturing are more evidenced in developed economies. For instance, in the US, Alanya et al. (2020) investigated how Lean Manufacturing may be applied in Peru to improve a textile SME's cutting process analyzing historical data from the study company. They found that the reprocessing process was reduced to 4%, a considerable reduction from 13% prior to the deployment of lean manufacturing. Additionally, the percentage of delayed processes decreased to 9.6%, about half of the initial 18% and the productivity index quadrupled from 0.4 to 1.2, proving that lean manufacturing works (Alanya, et al., 2020).

In developing economies like Nigeria, Okolocha & Anugwu (2022) noted that manufacturing companies will benefit substantially from implementing lean practices because lean manufacturing will help the sector reduce inherent variations with suppliers and demand from customers for greater effectiveness of the company. Ohiomah and Aigbavboa (2015) established that the biggest obstacle to effective lean practices in Nigeria is due to absence of top management support (35% after factoring cost of implementation (60% of 35%), unfamiliarity of lean tools) (25%); poor knowledge of lean tools by employees (25%); and poor technical-know-how of lean tools by employees (25%); poor knowledge of lean tools by employees (25%); and implementation cost of lean tools (15%).

Although there are numerous studies on lean manufacturing worldwide, findings of such studies cannot be extrapolated across the various countries particularly in developing economies such as Nigeria (Elkhairi et al., 2019). Much of the existing literature focuses on conceptual discussions of lean principles or broad challenges of industrial inefficiency, without providing empirical evidence linking lean practices to measurable operational outcomes (Linus & Daud, 2020). Lean manufacturing approaches have been the subject of a few studies in Nigeria, although their quantity, breadth, and methodological depth are still restricted. Few have specifically examined the connection between lean adoption and quantifiable operational outcomes in the cement industry (Okolocha & Anugwu, 2022). Thus, by investigating the implementation of lean manufacturing techniques and their impact on operational performance at Dangote Cement Factory, this study aims to close this gap.

Research Objectives

The specific objectives of this study are:

i. To examine operational staff's perceptions of the effectiveness of lean manufacturing practices in improving operational performance at Dangote Cement Factory.

ii. To assess lean manufacturing tools and techniques that contribute to enhancing key operational performance indicators.

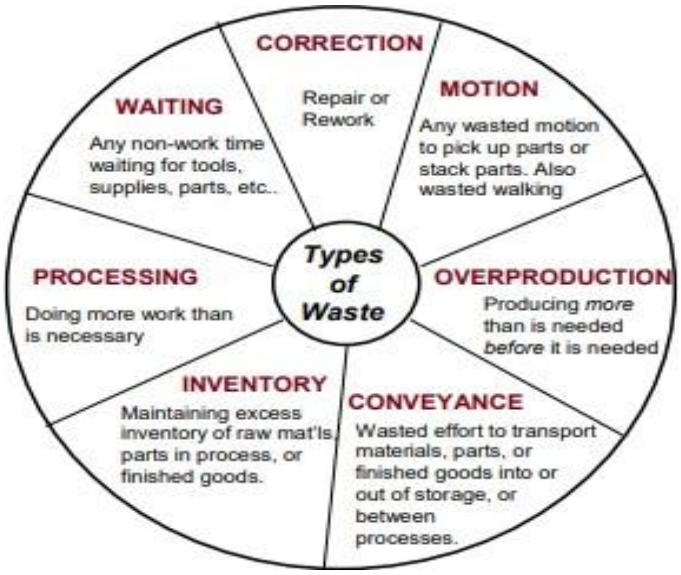
iii. To identify and analyze organizational barriers that affect the adoption and effectiveness of lean manufacturing practices.

iv. To evaluate how lean manufacturing practices influence overall operational performance at Dangote Cement Factory

LITERATURE REVIEW

According to ILO (2023), Lean is the methodical process of finding and removing waste via ongoing enhancement by flowing the product or service at the customer's request in an effort to achieve excellence. According to Taher & Bashar (2024), lean manufacturing, which was derived from the Toyota Production System (TPS), aims to enhance performance and minimize waste in production through continuous improvement (Kaizen) and active employee involvement. In lean manufacturing, two essential terms are employed: waste and value.; and (v) offering accessibility tools (Igbinovia & Ikenwe, 2018) as shown in Figure 1 below.

Figure 1. The 7 forms of waste (ILO, 2017)



According to Antonio (2024) and Crawford (2016), the core principles of lean manufacturing is divided into five: value identification, value mapping, production or manufacturing process flow, pull establishment, and seeking perfection. These principles as noted by Taher & Bashar (2024), help maximize efficiency and customer satisfaction. In this context, the value stream reflects the sequence of operations necessary to offer a product or service to the consumer.

Lean Tools & Practices

Lean tools are vast across various functions or elements of the manufacturing process. These tools enable organizations implement lean strategies and have been implemented by various organizations across the world. Due to the complexity of production process in cement manufacturing, characterized by heavy machinery, continuous processing, and high material flow, five key lean tools relevant to process-intensive industries (5S, Kaizen, Standard Operating Procedures, Heijunka, Value Stream Mapping, Total Productive Maintenance, and Just-In-Time) have been explained in this study and how they matter to cement production.

To start with, the 5S of lean manufacturing also known as the 5S of housekeeping are employed by organizations to ensure workplace organization and tidiness. These words originate from the Japanese words: Seiri (sort), Seiton (set-in-order), Seison (shine), Seiketsu (standardization), and Shisuke (sustain) Pennsylvania State University (PSU), (2020). This tool helps organizations improve efficiency, safety and employee morale (Taher & Bashar, 2024).

Building on this foundation, another key lean tool is Kaizen. This is a Japanese word meaning “change for the better” and is also popularly known as continuous improvement and it is the technique of making little, gradual adjustments to procedures, goods, or services in order to accomplish continual improvement (Oladipupo, et al., 2022;). In cement manufacturing, where process stability and quality consistency are critical, Kaizen supports defect reduction, process standardization, and operational discipline. The Kaizen can therefore offer the cement manufacturing industry in Nigeria the aforementioned benefits.

Closely related to Kaizen, the Just-In-Time (JIT) inventory management and according to Susanti et al. (2025), the Just-In-Time (JIT) inventory management approach seeks to improve production efficiency and cut waste. In cement operations, JIT supports raw material flow, reduces storage costs, and enhances scheduling efficiency.

In addition to JIT, the concept of Heijunka (level scheduling) which is a Japanese term referring to production levelling. According to Järvenpää & Lanz (2020), Heijunka strives to minimize lot sizes, in contrast to mass manufacturing, which favors large lot sizes. However, because it may call for frontloading or delaying delivery and maintaining inventories, this leveling occasionally runs counter to the JIT idea (Järvenpää & Lanz, 2020).

Value stream mapping (VSM) is another lean technique used to identify and depict the value stream on a single canvas in order to identify process waste. The traditional VSM looks at the manufacturing line's economics, primarily in relation to time-related metrics like cycle time, lead time, changeover time, etc. (Järvenpää & Lanz, 2020). It is particularly useful in cement manufacturing where long cycle times and complex logistics require systematic waste identification.

Similar to VSM is the Kanban system, which is a pull-based scheduling technique that controls the movement of work through the manufacturing process via visual cues. Kanban aids in maintaining optimal workflow and responsiveness to demand fluctuations by restricting work in progress and indicating when more work may begin (Taher & Bashar, 2024). In high-risk environments such as cement plants in Nigeria, SOPs are essential for minimizing operational errors and maintaining equipment reliability.

Lastly, the Total Productive Maintenance (TPM) is a lean tool and according to ILO (2023), TPM is a low-cost, human-intensive approach that involves the entire organization in a preventative maintenance program to maximize the efficacy of the equipment. Given the capital-intensive nature of cement production in Nigeria, TPM directly influences uptime, throughput, and cost efficiency.

In summary, these tools amongst several other tools create a system that can improve productivity, minimize waste, and strengthen operational performance, making them highly essential in the cement manufacturing industry in Nigeria. Also, these tools have been carefully selected because they align with the constructs measured. Therefore, the first and major hypothesis for this current study is developed to evaluate how adoption of lean tools in manufacturing will aid operational efficient in Nigeria.

Hypothesis 1: The adoption of lean tools and systems (ALM) significantly impacts on the operational performance (OE) in the manufacturing industry.

Barriers to Implementing Lean Manufacturing in Nigeria

According to Nwanya & Oko (2019), successful lean system implementation is impacted by non-integration of the different factors of production into a network for the manufacturing sector, good working culture and ethics for a disciplined environment, and lack of technical expertise. Abioye & Bello (2012) Aka et al. (2020), and Inuwa & Usman (2022) noted in their study that most manufacturing companies especially the SMEs have not fully embraced the lean concept either due to cost, leadership support and technical-know-how.

In addition, the surveys of the manufacturers and SMEs in Nigeria carried out by John (2024) have shown that 25% of them are not even familiar with the tools of lean, 30% of them have trouble finding skilled personnel, and resistance of the change by the management and by the employees is a common problem with 27% of the participants mentioning it as a significant problem. Fewer than 16% of MSMEs indicate any form of awareness on the lean techniques even though nearly 30% are willing to use them should they be provided with proper training and support (Ohiomah, 2015). Furthermore, Ohiomah and Aigbavboa (2015) established that the biggest obstacle to effective lean practices in Nigeria is due to absence of top management support (35% after factoring cost of implementation (60% of 35%), unfamiliarity of lean tools) (25%); poor knowledge of lean tools by employees (25%); and poor technical-know-how of lean tools by employees (25%); poor knowledge of lean tools by employees (25%).

Based on these findings, two major barriers that have been selected for this current study are the lean training and management support. With this, the second hypothesis for this current study have been developed.

Hypothesis 2: The availability of lean training resources and management support (LTMS) significantly impact on lean adoption (ALM) in the manufacturing industry

Also, this current study posits that lean training and management support can moderate the level of impact lean practices can have on operational efficiency. Where operational staffs or employees are given the proper training on lean tools, this study hypothesize that the strength of impact of adoption is envisaged to increase and vice-versa. This led to the development of the third hypothesis for this current study as shown below.

Hypothesis 3: Lean training and management support (LTMS) moderates the impacts of lean adoption (ALM) on operational efficiency (OE) in the Manufacturing industry

Theoretical Framework

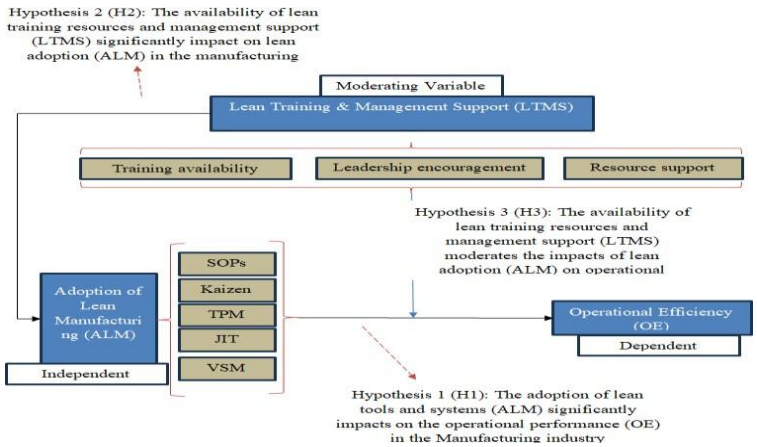
For this study, there are two theoretical perspectives selected - the Unified Theory of Acceptance and Use of Technology (UTAUT) and the Theory of constraints (TOC). Collectively, these frameworks describe the effects of organizational support on the adoption of lean and the impact of lean practices on enhanced operational efficiency.

UTAUT presents a valuable explanatory framework concerning the way employees embrace and implement lean practices if lean is conceptualized as an organizational innovation. According to this model, performance expectancy, effort expectancy, social influence, and facilitating conditions determine the willingness of people to adopt new systems (Venkatesh et al., 2003). In this paper, Lean Training and Management Support (LTMS) will fit the facilitating conditions and social influence constructs. An enabling environment for lean practices is developed through intensive training, leadership support and availability of resources, thus making employees more likely to adopt lean tools and practices. UTAUT consequently affirms the correlation between LTMS and the Adoption of Lean Manufacturing (ALM) that roots LTMS as a precursor that enhances lean adoption.

Theory of constraints (TOC) on the other hand is a perspective that compliments the UTAUT view by elaborating on how the adoption of lean enhances the operations and it conceptualized by Eliyahu Goldratt in 1947. TOC states that organizations cannot do better because they have certain constraints, and these constraints can be improved once they are identified and dealt with in an orderly manner (Dutta, 2023). Lean tools like Kaizen, VSM, JIT, and TPM have a direct focus on bottlenecks, the variability of processes, and the flow improvements, which leads to more operational efficiency (OE) (Panwar, et al., 2018).. TOC thus promotes the direct correlation between ALM and OE.

Based on these two frameworks, the research framework developed for this study is shown in Figure 3 below and based on this framework and supporting literature reviews, 3 hypotheses have been developed.

Figure 2. Research Framework



RESEARCH METHODOLOGY

This study adopted an explanatory, cross-sectional case study design using a quantitative survey strategy (this was selected to measure relationship between variables quantitatively rather than the initially proposed qualitative study). The design is suitable because it tests cause-effect relationships between lean adoption and operational performance at one point in time (Saunders et al., 2023). Also, these tests and measurements will help answer the various research questions in a quantitative manner. The data gathered was analyzed using the IBM SPSS. For the moderation effect, the Hayes (2025) PROCESS macro was employed to analyze the effect of the moderating variable on the independent and dependent variables.

The target population for this study is the employees of Dangote cement Plc., Nigeria. According to Stock Analysis (2025), Dangote cement Nigeria has a total of 21,649 employees in 2024. Using the SurveyMonkey sample size calculator at 7% margin of error, confidence level at 85% and population size at 21649, the estimated sample size is 106.

Therefore, 106 employees working in Dangote cement Plc. Nigeria will be surveyed for this study. While non-probability sampling is practical, it introduces limitations such as potential selection bias and reduced generalizability. These limitations are acknowledged and addressed in the validity section.

The Cronbach's Alpha reliability test was conducted to measure the reliability of the construct variables (Bonett & Wright, 2014) According to Ahmad et al. (2024), an alpha value below 0.6 has poor reliability and is unacceptable; alpha value between 0.60 and 0.69 is questionable; between 0.7 to 0.79 is acceptable; between 0.8 to 0.89 has strong consistency; and 0.9 above has very high consistency. The Construct Validity test was also tested by applying Exploratory Factor Analysis (EFA) in SPSS to confirm that questionnaire items cluster appropriately under their intended constructs. The KMO and Barlett's test was also conducted to determine the appropriateness of data to the Exploratory Factor Analysis (EFA), which further aids the construct validity.

RESULTS AND DISCUSSION

The total number of participants who responded to the survey is 100 while the number of responses expected from the sample size calculated is 106. The demographics of participants of the survey is presented in the Table 1 below.

Table 1. Demographical distribution

Demography	Categories	Frequency	Percent
Gender	Female	16	16%
	Male	84	84%
Years of Experience	6–10 years	33	33%
	2 – 5 years	2	2%
	More than 10 years	65	65%
Education	Bachelor's Degree	45	45%
	Master's Degree or Higher	50	50%
	Technical/Vocational Diploma	5	5%
	Engineer	17	17%

Role in Dangote	Manager	40	40%
	Operator	28	28%
	Supervisor	2	2%
	Technician	13	13%
Department	Maintenance	16	16%
	Production	41	41%
	Quality Control	14	14%
	Supply Chain/Logistics	29	29%
Years Working in Dangote	1–3 years	14	14%
	4–7 years	28	28%
	Less than 1 year	2	2%
	More than 7 years	56	56%

The demographics show that the study has been based on a well-informed, experienced, and multidisciplinary workforce, which offers credible data on the lean practices and operational performance.

Descriptive Analysis

The questions for each variable have been labelled for easy identification as shown in Table 1 below. ALM represents measurement items for adoption of lean manufacturing and the six items are named ALM1 To ALM6. This is similar for lean training and management support (LTMS as LTMS 1 to LTMS6) and operational efficiency (OE as OE1 to OE6).

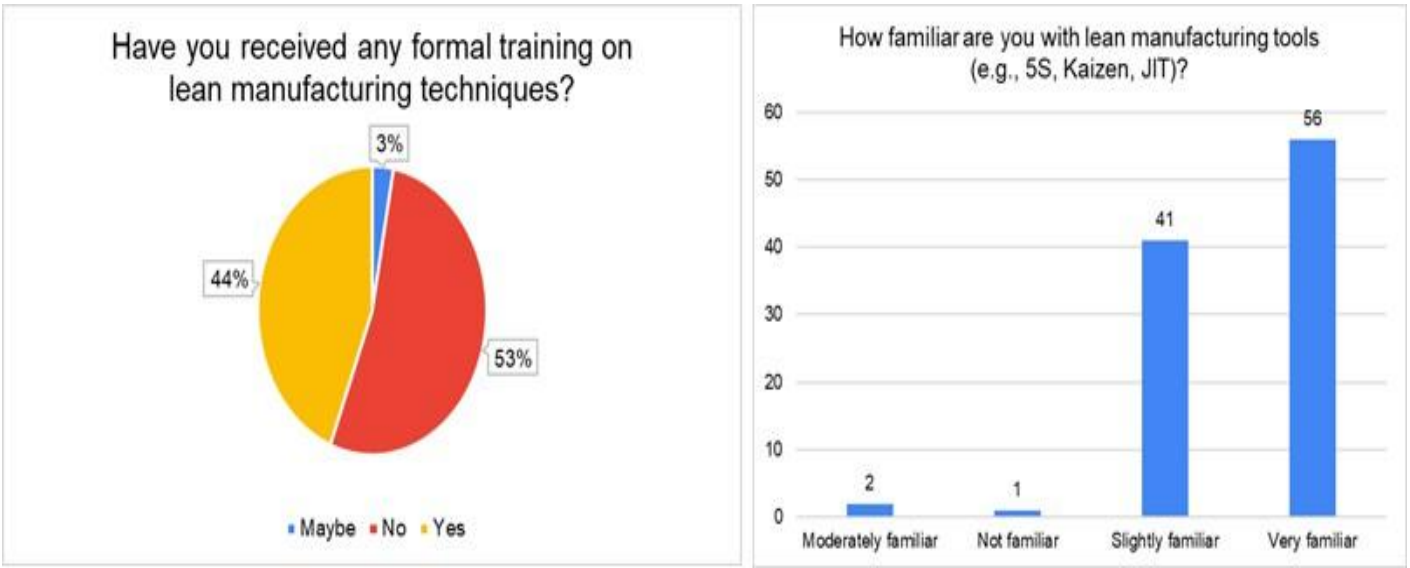
Table 2. Descriptive analysis

Variable	Constructs	Mean	Std. Deviation	Skewness		Kurtosis	
		Statistic	Statistic	Statistic	Std. Error	Statistic	Std. Error
LTMS	LTMS1	4.36	0.612	-0.390	0.241	-0.640	0.478
	LTMS2	4.10	0.772	-0.444	0.241	-0.423	0.478
	LTMS3	4.03	0.413	0.215	0.241	3.062	0.478
	LTMS4	4.39	0.737	-1.232	0.241	1.570	0.478
	LTMS5	3.94	0.312	-3.475	0.241	18.789	0.478
	LTMS6	3.91	0.288	-2.909	0.241	6.595	0.478
ALM	ALM2	4.00	0.246	0.000	0.241	14.438	0.478
	ALM3	4.01	0.174	1.787	0.241	31.754	0.478

	ALM4	4.89	0.345	-3.254	0.241	10.845	0.478
	ALM5	4.05	0.297	1.442	0.241	8.081	0.478
	ALM6	4.10	0.438	0.515	0.241	1.910	0.478
	ALM7	4.11	0.314	2.531	0.241	4.496	0.478
OE	OE1	4.01	0.225	0.774	0.241	17.872	0.478
	OE2	4.01	0.174	1.787	0.241	31.754	0.478
	OE3	4.02	0.200	2.270	0.241	22.728	0.478
	OE4	4.03	0.223	2.385	0.241	17.268	0.478
	OE5	4.92	0.307	-4.149	0.241	18.388	0.478
	OE6	4.87	0.418	-3.388	0.241	11.202	0.478
	OE7	4.08	0.273	3.144	0.241	8.043	0.478
	OE8	4.35	0.479	0.639	0.241	-1.625	0.478

The descriptive statistics presented in Table 2 above showed that the adoption of lean (ALM) is positively rated and operational efficiency (OE) benefits are highly rated, and this can be traced to the good support and resources provided by the management. This infers that leadership commitment is a key issue that can affect the level and the success of lean implementation.

Figure 3. Formal training of participants on Lean vs Level of familiarity of participants with Lean tools



As shown in Figure 3, the categories of employees who have been trained on lean formally (44%) are lower as compared to those who have not undergone such training (53%) which implies that there is a divide that could undermine the integrity of the lean training. Nevertheless, 97% of employees also say that they are conversant with lean tools, which demonstrates a good informal learning with exposure on the job. This low formal training and high familiarity disparity underscores the gap in training and management support as supported by the results of the study that Lean Training and Management Support (LTMS) is the key to enhancing the role of Lean Adoption (ALM) in Operational Efficiency (OE) as hypothesized in H2 and H3.

Reliability and Validity

Table 3. Reliability Test

Construct variable	Cronbach's Alpha	Items measured
Lean Training & Management Support (LTMS)	0.732	6
Adoption of Lean Manufacturing (ALM)	0.717	6
Operational Efficiency (OE)	0.889	8

The reliability results as shown in Table 3 above informs that for Lean Training & Management Support (LTMS), an alpha value of 0.732 was measured which is reliable.. Similarly for the Adoption of Lean Management (ALM), the alpha value measured was 0.717 which is reliable. Lastly, for Operational Efficiency (OE), the Cronbach's Alpha was 0.889, also indicating strong internal consistency among the eight items.

Table 4. Validity Test

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.619
Bartlett's Test of Sphericity	Approx. Chi-Square	1875.779
	df	231
	Sig.	0.000

From the Table 4 above, the Bartlett's Test of Sphericity was significant (Chi-Square = 1875.779, $p < .001$), indicating that the correlation matrix is not an identity matrix and that the variables are sufficiently correlated for factor analysis. Bartlett's Test of Sphericity was therefore significant ($p < .001$), indicating that the correlation matrix is appropriate for factor extraction and that the items share meaningful relationships. The KMO value of 0.619 indicates mediocre but acceptable sampling adequacy, suggesting that the dataset contains sufficient shared variance among items to proceed with factor analysis.

Inferential Analysis - Hypothesis 1 Regression Model

Hypothesis 1 (H1): The adoption of lean tools and systems (ALM) significantly impacts on the operational performance (OE) in the manufacturing industry

This model examines the relationship between the adoption of lean manufacturing tools and systems on operational performance in the manufacturing industry.

Table 5. Regression model for hypothesis 1

Model 1									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	Coefficient	F Change	df2	Sig. P-value
1	0.602[a]	0.362	0.356	0.11345	0.362	0.570	55.676	98	<0.000

a. Predictors: (Constant), ALM
b. Dependent Variable: OE

The model in Table 5 above shows that the correlation coefficient (R) is 0.602, indicating a strong positive association between ALM and OE. The coefficient of determination (R^2) is 0.362, which means that approximately 36.2% of the variation in operational efficiency can be accounted for by the adoption of lean manufacturing practices.

Lastly, the coefficient (β) for ALM is 0.570 and this implies that for every one-unit increase in lean manufacturing adoption, operational efficiency increases by approximately 0.570 units. Overall, the regression results provide strong evidence that the adoption of lean manufacturing significantly and positively predicts operational efficiency in the manufacturing industry, and the hypothesis is therefore accepted.

Inferential Analysis - Hypothesis 2 Regression Model

Hypothesis 2 (H2): The availability of lean training resources and management support (LTMS) significantly impact on lean adoption (ALM) in the manufacturing industry.

This model assesses the extent to which lean training resources and management support (LTMS) implemented on adopting lean manufacturing tools and systems (ALM) in the manufacturing industry.

Table 6. Regression model for hypothesis 2

Model 2									
Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	Coefficient	F Change	df2	Sig. p-value
2	0.450[a]	0.203	0.194	0.13400	0.203	0.184	24.902	98	<0.001
a. Predictors: (Constant), LTMS									
b. Dependent Variable: ALM									

The model in Table 6 above shows that the correlation coefficient (R) is 0.450, indicating a strong positive correlation between ALM and LTMS. The coefficient of determination (R^2) is 0.203, which means that approximately 20.3% of the variation in operational efficiency can be explained by the adoption of lean manufacturing practices.

Lastly, the coefficient (β) for LTMS is 0.184 and this implies that for every one-unit increase in lean manufacturing adoption, operational efficiency increases by approximately 0.184 units. Overall, the regression results provide strong evidence that the training employees in lean tools and more management support significantly and positively predicts adoption of lean manufacturing and the hypothesis is therefore accepted.

Inferential Analysis - Hypothesis 3 Regression Model

Hypothesis 3 (H3): The availability of lean training resources and management support (LTMS) moderates the relationship between lean adoption (ALM) and operational efficiency (OE) in the Manufacturing industry.

To test the mediating or moderating effect of Lean Training and Management Support (LTMS) on Adoption of Lean Manufacturing (ALM) and Operational Efficiency (OE), the Hayes (2025) PROCESS, a regression-based modelling tool was employed at 5000 bootstrap confidence intervals.

Given that LTMS was conceptualized as a moderator in the conceptual framework, the moderation analysis was conducted using PROCESS. The moderation results are presented in Tables 7 and 8 below.

Table 7. Moderation Analysis Results

Predictor	Coefficient (β)	SE	t-value	p-value	LLCI	ULCI
Constant	4.2961	0.0114	378.2442		4.2735	4.3186
ALM (X)	0.3045	0.1126	2.7042	0.0081	0.081	0.5281
LTMS (W)	0.0225	0.037	0.6087	0.5441	0.0959	0.0509
ALM × LTMS	0.4057	0.1312	3.0924	0.0026	0.6661	

Table 7. Moderation Model fit statistics

Statistic	Value
R^2 Change (Interaction)	0.058
F-change	9.563
df1, df2	1, 96
p-value	0.003

The moderation analysis examined whether Lean Training and Management Support (LTMS) influences the strength of the relationship between Adoption of Lean Manufacturing (ALM) and Operational Efficiency (OE). As shown in Table 7, ALM has a significant positive effect on OE ($\beta = 0.3045$, $p = 0.0081$), indicating that higher adoption of lean practices is associated with improved operational efficiency. LTMS, however, does not have a significant direct effect on OE ($p = 0.5441$), suggesting that training and management support alone do not independently predict operational performance.

The interaction term between ALM and LTMS is statistically significant ($\beta = 0.4057$, $p = 0.0026$), demonstrating that LTMS moderates the relationship between ALM and OE. This means that the effect of lean adoption on operational efficiency depends on the level of training and management support available within the organization. The positive coefficient indicates that as LTMS increases, the relationship between ALM and OE changes in a meaningful way. Table 7 further confirms the presence of moderation. The inclusion of the interaction term results in a significant increase in explained variance ($R^2 = 0.058$, $p = 0.003$), meaning that LTMS contributes an additional 5.8% explanatory power to the model beyond the direct effects of ALM and LTMS. This demonstrates that LTMS plays a meaningful role in shaping how lean adoption translates into operational performance.

Overall, these results show that while lean adoption directly improves operational efficiency, the level of training and management support significantly influences the strength of this relationship.

In conclusion, the results support H1 and H2, and confirm H3 by demonstrating that LTMS significantly moderates the relationship between ALM and OE. These findings are discussed in subsequent sections below.

DISCUSSION OF FINDINGS

Following the data analysis of data obtained at Dangote Cement Factory, it was found that general perception of operational staff on lean manufacturing practices works well in enhancing operational performance in the areas of productivity, efficiency, and product quality. This impression is consistent with the results of Saleem and Leo

(2022), who determined that lean systems like Just-in-Time and Total Quality Management are effective in enhancing performance in organizations with processes that are streamlined and with reduced waste.

Meanwhile, this research has also noted that, although the staff are aware of the advantages of practicing lean, their views are moderated by the lack of formal training and management support. It is correlated with the results of Ohiomah and Aigbavboa (2015) who observed the absence of familiarity with lean tools among employees and the inadequacy of commitment of the top management as the primary obstacles to successful implementation of lean in Nigeria. Barrier-wise, this study revealed that the major barriers to lean implementation in Dangote Cement are lack of formal training to staff, high cost of implementation, lack of technical skills and inconsistent management support. These barriers are similar to those in the literature, where Ohiomah and Aigbavboa (2015).

Finaly, this paper showed that lean practices have predicted positively and quantitatively on overall operational performance in Dangote Cement. Employees indicated that they had better productivity, efficiency, quality of the products, and delivery within the required time, and the regression has validated that the implementation of lean is a significant predictor of the efficiency of operations. These results are consistent with those of Saleem and Leo (2022), who have discovered that Just-in-Time and Total Quality Management as lean practices can increase the performance of organizations and with Susanty et al. (2022), who have concluded that adoption of lean can improve operational and business performance of SMEs. In addition, Holmemo, Ingvaldsen, and Powell (2023) underlined the importance of leadership commitment and employee engagement, which have also been reflected in this research with the employees stating that without regular management support and structured training, the gains of lean might not be long-term.

CONCLUSION

This study explored the adoption of lean manufacturing and its influence on operational performance at Dangote Cement Factory. The findings suggest that the lean practices including Kaizen, Standard Operating Procedures, Value Stream Mapping, and Total Productive Maintenance have had a positive impact on the productivity, efficiency, and quality. The results are consistent with the evidence about developed economies, in which lean practices have been reported to decrease the level of waste, decreased lead times, and improved competitiveness (FloresMeza et al., 2020; Henao et al., 2019).

It was also found in the study that LTMS is a significant moderator of lean adoption whereby training availability, leadership encouragement and resource support should be considered as enablers of lean implementation. This is also in line with the Nigerian and international literature that emphasizes managerial commitment and the capability of the employees as key success factors in the implementation of lean (Ohiomah and Aigbavboa, 2015; Abioye and Bello, 2012).

One of the main contributions that this study made is that it confirmed the role of LTMS as a moderator and not as a mediator. The moderation analysis demonstrated that LTMS has a great influence on the strength of the relationship between ALM and operational efficiency. In particular, the impact that ALM has on operational efficiency is the most optimistic in cases when LTMS is moderate. This implies that when the training and management support are carefully introduced to operators, lean practices within the organization is moderately increased.

Lastly, the research points out the methodological weaknesses such as non-probability sampling, single-case study, and moderate KMO value, which limit the extrapolation of results. Nevertheless, the research is relevant and informative on the functioning of lean practices in a large manufacturing organization in Nigeria as well as on the significance of organizational support in defining the lean results.

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