

Technology Management Practices and Operational Efficiency of Pharmaceutical Manufacturing Firms in Enugu State, Nigeria

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Abstract

The study evaluated technology management practices and operational efficiency of pharmaceutical Manufacturing Firms in Enugu State, Nigeria. The specific objectives are to: Examine the relationship between technology acquisition and production speed and Evaluate the technology integration and cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria. The study used the descriptive survey design approach. The primary source of data was the administration of questionnaire. A total population of 1144 staff were used. The adequate sample size of 288, using Freund and William's statistic formula at 5 percent margin of error was used. 244 respondents returned the questionnaire and accurately filled. Data was presented and analyzed and the hypotheses using Z - test. The findings indicated that Technology acquisition had significant positive relationship with production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria, Z (9.411, P.<. 05) and Technology integration had significant positive relationship with cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria, Z (9.091, P.<. 05). The study concluded that technology acquisition and technology integration had significant positive relationship with production speed and cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria. The study recommended among others that Pharmaceutical manufacturing firms in Enugu State should prioritize continuous investment in modern and advanced production technologies, as this will enhance automation, streamline production processes, and significantly improve production speed, enabling them to meet market demand more efficiently.

Keywords: Technology Management Practices, Technology Acquisition, Production Speed, Technology Integration, Cost Reduction.

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Introduction

Technology has become a critical driver of productivity and competitiveness in modern manufacturing industries. In recent years, organizations have increasingly relied on effective technology management practices to enhance production processes, improve product quality, and achieve operational excellence. Technology management involves the systematic planning, acquisition, development, and utilization of technological resources to support organizational objectives and create competitive advantage. Operational efficiency refers to the ability of a firm to optimally utilize its resources, including labor, equipment, and technology, to produce goods and services with minimal waste and cost while maintaining high quality standards. In manufacturing industries, operational efficiency is often achieved through the integration of modern production technologies, digital transformation practices, and efficient production management systems (Tian et al., 2023; Wahyunto, 2024).

In developing economies such as Nigeria, the pharmaceutical manufacturing sector plays a significant role in supporting healthcare delivery, promoting industrial development, and reducing dependence on imported medicines. Despite its importance, many pharmaceutical manufacturing firms face challenges such as inadequate technological infrastructure, limited research and development capacity, and inefficient technology management systems. These challenges often affect their ability to maintain consistent production quality and achieve optimal operational efficiency. Evidence from studies on manufacturing firms in Nigeria shows that effective management systems and technological practices significantly contribute to improved operational performance and organizational effectiveness (Shehu, Jimoh & Shehu, 2025).

Within Enugu State, pharmaceutical manufacturing firms constitute an important part of the region's industrial sector and contribute to employment generation and economic growth. However, the increasing technological demands of the pharmaceutical industry require firms to adopt efficient technology management practices to remain competitive and operationally efficient. Consequently, this study examines the relationship between technology management practices and operational efficiency of pharmaceutical manufacturing firms in Enugu State, Nigeria. The study aims to provide empirical insights that will assist managers, policymakers, and industry stakeholders in improving technological capabilities and enhancing operational performance in the pharmaceutical manufacturing sector.

Statement of Problem

Ideally, pharmaceutical manufacturing firms are expected to operate with advanced technological systems, effective technology management practices, and efficient production processes that ensure high product quality, regulatory compliance, and optimal utilization of resources. In a highly regulated and technology-driven industry such as pharmaceutical manufacturing, firms are expected to strategically manage technological resources through continuous innovation, regular upgrading of production equipment, effective research and development activities, and proper integration of digital and automated systems into their operations. When technology is effectively managed, it enhances productivity, reduces operational costs, improves product consistency, and strengthens the competitive position of pharmaceutical firms within the healthcare sector.

However, in many developing economies such as Nigeria, pharmaceutical manufacturing firms continue to face several challenges related to ineffective technology management practices. These challenges include inadequate technological infrastructure, obsolete production equipment, limited investment in research and development, poor technological integration, and insufficient technical skills among employees. In Enugu State, where a number of pharmaceutical manufacturing firms operate, these issues often hinder firms from fully utilizing available technological resources to improve operational efficiency. As a result, many firms experience production delays,

high operational costs, equipment breakdowns, low productivity, and difficulties in meeting regulatory and quality standards required in the pharmaceutical industry.

If these technology management challenges are not adequately addressed, the consequences may be severe for both the firms and the broader healthcare system. Poor operational efficiency may lead to reduced production capacity, increased cost of medicines, reduced competitiveness of local pharmaceutical firms, and continued dependence on imported pharmaceutical products. Furthermore, inefficient production processes may affect the consistent supply of quality medicines, which could negatively impact healthcare delivery and public health outcomes. Therefore, there is a need to examine how technology management practices influence operational efficiency in pharmaceutical manufacturing firms in Enugu State, with the aim of identifying strategies that can enhance productivity, improve technological capability, and strengthen the performance of the pharmaceutical manufacturing sector in Nigeria.

Objectives of the Study

The main aim of the study was to examine technology management practices and operational efficiency of pharmaceutical Manufacturing Firms in Enugu State, Nigeria. The specific objectives are to:

- i. Examine the relationship between technology acquisition and production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria.
- ii. Evaluate the technology integration and cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria.

Research Questions

The following Research questions guided the study

- i. What is the relationship between technology acquisition and production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria?
- ii. What is the technology integration and cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria?

Statement of Research Hypothesis

The following Hypotheses guided the study

- i. Technology acquisition has relationship with production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria.
- ii. Technology integration has relationship with cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria

Scope of the Study

Content Scope: The study focuses on technology management practices and their influence on operational efficiency in pharmaceutical manufacturing firms. Specifically, it examines key dimensions of technology management practices such as technology acquisition and technology integration, while operational efficiency is measured using indicators like production speed and cost reduction.

Unit Scope: The study is limited to pharmaceutical manufacturing firms, with emphasis on management and operational staff who are directly involved in technology usage, production processes, and decision-making within the organizations.

Geographical Scope: The study is confined to pharmaceutical manufacturing firms located in Enugu State, Nigeria, thereby providing context-specific insights relevant to the region.

Review of Related Literature

Conceptual Review

Technology

Technology refers to the application of scientific knowledge, technical skills, tools, equipment, and processes used to transform raw materials into useful products and services. In manufacturing industries, technology includes production machinery, automated systems, digital tools, and specialized techniques that support efficient production and innovation. In pharmaceutical manufacturing firms, technology is particularly important because the production of medicines requires high levels of precision, quality control, and compliance with regulatory standards. Modern pharmaceutical manufacturing relies on advanced technologies such as automated production lines, computerized quality monitoring systems, and laboratory technologies that enhance accuracy, reduce human error, and improve production efficiency (Katina, Cash, Caldwell, Beck, & Katina, 2023; Sultana, Maseera, Rahamanulla, & Misiriya, 2023).

Management

Management refers to the process of planning, organizing, directing, and controlling organizational resources in order to achieve predetermined goals efficiently and effectively. It involves coordinating human, financial, technological, and material resources to ensure that organizational activities are carried out in a structured and productive manner. In manufacturing organizations, management plays a critical role in guiding operational activities, allocating resources, supervising employees, and ensuring that production processes meet organizational objectives. Effective management enables firms to improve productivity, maintain quality standards, and respond effectively to environmental and technological changes (Daft, 2021; Robbins & Coulter, 2022).

Practices

Practices refer to the regular activities, methods, procedures, and actions that organizations adopt and consistently apply in carrying out their operations and achieving organizational objectives. In the context of pharmaceutical manufacturing firms, practices refer to the specific methods and procedures adopted by organizations in managing production processes, technological systems, quality control, and operational activities. Examples include technology management practices, quality management practices, production management practices, and research and development practices. These practices help firms standardize operations, maintain regulatory compliance, and improve efficiency in the production of pharmaceutical products. Effective organizational practices enable pharmaceutical manufacturing firms to optimize resources, minimize operational errors, and ensure the consistent production of safe and high-quality medicines (Gavetti, et al., 2023).

Technology Management Practices

Technology management practices refer to the systematic activities, strategies, and procedures that organizations adopt to plan, acquire, develop, implement, and control technological resources in order to achieve organizational

goals. These practices involve managing technological innovations, integrating new technologies into production processes, maintaining technological infrastructure, and ensuring that technology supports organizational efficiency and competitiveness. Technology management practices also include activities such as technology acquisition, technology transfer, research and development, technology forecasting, and the continuous improvement of technological systems. According to Cetindamar, Phaal and Probert (2022), technology management practices enable organizations to align technological capabilities with business strategies, thereby improving innovation and operational performance.

Components of Technology Management Practices

The key components of technology management practices in organizations, particularly in pharmaceutical manufacturing firms, include the following: Technology Acquisition, Research and Development (R&D), Technology Implementation and Integration, Technology Maintenance and Upgrading, Technology Evaluation and Control, Technology Forecasting and Planning, Knowledge and Skills Management according to the following authors (Cetindamar, Phaal, & Probert, 2022; Kalko, Erena, & Debele, 2022; Sultana, Maseera, Rahamanulla, & Misiriya, 2023).

Components of Technology Management Practices that formed part of the objectives

Technology acquisition

Technology acquisition refers to the systematic process through which organizations identify, select, and obtain the technological resources necessary to support their operational and strategic objectives. In pharmaceutical manufacturing firms, technology acquisition involves procuring advanced machinery, production equipment, laboratory instruments, digital systems, and software that are critical for drug formulation, quality control, packaging, and distribution. This process ensures that firms have access to the appropriate technological tools to enhance production efficiency, maintain product quality, and comply with stringent regulatory standards. Cetindamar, et al., (2022), technology acquisition is a foundational component of technology management, as it provides the firm with the means to innovate, modernize processes, and remain competitive in a rapidly evolving industrial landscape.

In the pharmaceutical manufacturing context, technology acquisition not only involves purchasing or leasing equipment but also includes activities such as technology licensing, technology transfer, collaboration with research institutions, and adopting digital and automated systems. Effective technology acquisition allows firms to introduce new drug formulations, improve existing production processes, and reduce production errors, ultimately enhancing operational efficiency and product reliability. Studies have highlighted that firms that strategically acquire and integrate advanced technologies are better positioned to respond to market demands, meet international quality standards, and sustain long-term competitiveness in the pharmaceutical sector (Kalko, Erena, & Debele, 2022; Sultana, Maseera, Rahamanulla, & Misiriya, 2023). Therefore, technology acquisition serves as a critical driver for innovation, operational excellence, and overall growth in pharmaceutical manufacturing firms.

Technology integration

Technology integration refers to the process of combining newly acquired or existing technological tools, systems, and processes into the operational framework of an organization to improve efficiency, productivity, and quality. In pharmaceutical manufacturing firms, technology integration involves the seamless incorporation of production equipment, automated systems, laboratory instruments, and digital technologies into the firm's production, quality control, and distribution processes. The goal of technology integration is to ensure that all technological resources

work cohesively to optimize production workflows, reduce errors, enhance regulatory compliance, and support innovation. Cetindamar, et al., (2022), technology integration is a critical component of technology management because it enables firms to convert technological investments into tangible operational benefits.

Operational

Operational efficiency refers to the ability of an organization to maximize output while minimizing the use of resources, including time, labor, materials, and costs, without compromising the quality of its products or services. In pharmaceutical manufacturing firms, operational efficiency emphasizes the optimization of production processes, reduction of waste, timely delivery of medicines, and adherence to regulatory and quality standards. Achieving operational efficiency ensures that pharmaceutical firms can produce safe, effective, and high-quality drugs at competitive costs while maintaining consistent supply to meet market and healthcare demands. Tian et al. (2023), operational efficiency in manufacturing is closely linked to effective resource utilization, process optimization, and integration of advanced technological systems to enhance productivity.

Efficiency

Efficiency refers to the ability of an organization to achieve maximum output or results with minimum input of resources such as time, labor, materials, and capital. In pharmaceutical manufacturing firms, efficiency emphasizes producing high-quality medicines while minimizing wastage, reducing production costs, and optimizing the use of technological and human resources. Efficient operations are crucial in the pharmaceutical sector because they directly impact product availability, affordability, and compliance with regulatory standards. According to Tian et al. (2023), efficiency in manufacturing is closely linked to process optimization, technological integration, and effective resource management, all of which contribute to improved productivity and competitive advantage.

Operational Efficiency

Operational efficiency refers to the ability of an organization to maximize productivity while minimizing the use of resources such as time, labor, materials, and costs, without compromising the quality of its products or services. In pharmaceutical manufacturing firms, operational efficiency emphasizes the optimization of production processes, reduction of waste, timely delivery of medicines, and strict adherence to regulatory and quality standards. It measures how well a firm can convert its inputs such as raw materials, human resources, and technology into high-quality pharmaceutical products in the most cost-effective manner. Tian et al. (2023), operational efficiency is enhanced when firms integrate advanced technological systems, streamline workflows, and implement best production and quality management practices. Pharmaceutical firms with effective operational efficiency practices experience reduced operational costs, consistent product quality, and improved competitiveness in the global market (Shehu, Jimoh, & Shehu, 2025; Wahyunto, 2024).

Components of Operational Efficiency

The main components include: Production Speed, Cost Reduction, Resource Utilization, Quality Management, Process Optimization, Technology Integration, Inventory and Supply Chain Management and Time Management according to the following authors (Shehu, Jimoh, & Shehu, 2025; Tian, Chen, Tian, Huang, & Hu, 2023; Wahyunto, 2024; Sultana, Maseera, Rahamanulla, & Misiriya, 2023).

Components of Operational Efficiency that formed part of the objectives

Production speed

Production speed refers to the rate at which a manufacturing firm converts raw materials into finished products within a given period. In pharmaceutical manufacturing firms, production speed is a critical aspect of operational performance, as it determines the firm's ability to meet market demand, reduce lead times, and ensure timely delivery of medicines. High production speed allows pharmaceutical firms to respond quickly to fluctuations in demand, maintain adequate inventory levels, and ensure that essential drugs are available when needed. Tian et al. (2023), production speed in manufacturing is closely linked to process optimization, automation, and effective use of technology, which collectively improve productivity and reduce bottlenecks in production workflows. Pharmaceutical firms that combine technology management practices with optimized production workflows are able to increase production speed without compromising product quality or regulatory compliance (Shehu, Jimoh, & Shehu, 2025; Wahyunto, 2024). Therefore, production speed is a vital component of operational performance, reflecting a firm's ability to efficiently utilize resources to produce high-quality medicines within optimal time frames.

Cost reduction

Cost reduction refers to the strategic efforts and practices that organizations adopt to lower operational and production expenses while maintaining or improving the quality of their products or services. In pharmaceutical manufacturing firms, cost reduction is critical because production involves high expenses related to raw materials, sophisticated equipment, quality control, regulatory compliance, and skilled labor. Effective cost reduction enables firms to maximize profitability, allocate resources efficiently, and maintain competitive pricing in the pharmaceutical market. Tian et al. (2023), cost reduction in manufacturing is often achieved through process optimization, waste minimization, efficient resource utilization, and the adoption of advanced technologies.

Theoretical Framework

In this study, two relevant theories provide a strong conceptual foundation: The Resource-Based View (RBV) Theory and the Technology-Organization-Environment (TOE) Framework. These theories help explain how technological resources and organizational practices influence operational performance in pharmaceutical firms.

The study was anchored on the Resource-Based View (RBV) Theory because it explains that effective management of valuable technological resources enhances operational efficiency, enabling pharmaceutical manufacturing firms in Enugu State to improve production speed, reduce costs, and achieve sustained competitive advantage.

Resource-Based View (RBV) Theory, developed by Barney (1991), posits that an organization's resources and capabilities are critical determinants of its competitive advantage and performance. According to RBV, firms that possess valuable, rare, inimitable, and non-substitutable resources can achieve superior performance compared to competitors. In the context of pharmaceutical manufacturing, technology management practices including technology acquisition, integration, and maintenance are considered strategic resources that enhance operational efficiency.

Technology-Organization-Environment (TOE) Framework, proposed by Tornatzky and Fleischer (1990), suggests that the adoption and effective use of technology in organizations are influenced by three factors: technological context, organizational context, and environmental context. Applied to pharmaceutical manufacturing firms in Enugu State, the TOE framework explains how the interplay of these factors affects the adoption of technology management practices and operational efficiency. Together, the RBV and TOE theories provide a comprehensive understanding

of how technology management practices serve as strategic resources and how contextual factors influence their effectiveness in improving operational efficiency in pharmaceutical manufacturing firms.

Empirical Review

Technology acquisition and production speed

Edeh et al (2023) conducted study on Total Quality Management Practices and Performance of Pharmaceutical Firms in Enugu State. The study evaluated the Total quality management practices and performance of pharmaceutical firms in Enugu State. The population of the study consists of five (5) selected three hundred and seventy-two (372) staff of Pharmaceutical manufacturing companies in Enugu state, Nigeria. The whole population was used due to small number. The study used the descriptive survey design approach. The primary source of data was the administration of questionnaire. The hypotheses were tested using Pearson correlation (r). The findings indicated that Customer focus had significant positive relationship with profitability of pharmaceutical firms in Enugu State, ($r=.412 <.982$, $p<.05$). Continual improvement had significant positive relationship with volume of sales of pharmaceutical firms in Enugu State, ($r=.367<.835$, $p<.05$).

Ayo-Lawal et al (2023) carried out a study on mapping the strength of sectoral innovation system in the Nigerian pharmaceutical industry: Empirical evidence. Data were obtained from thirty-two manufacturing pharma firms, and sixty-nine researchers from faculties of pharmacy across Nigerian universities and three key research institutes with drug-related mandates. The results reveal poor synergy in research among the actors, and weak academia-industry interaction as only about one-third of industrial firms indicated active collaboration with knowledge institutions. More pertinently, over two-third of researchers in universities rated research-industry collaborations on most of the key aspects considered to be at least weak, Contract research and joint R&D activities were equally rated weak.

Okoroafor et al (2025) examined the Strategic Outsourcing and Performance of Pharmaceutical Firms in Enugu State. The study used the descriptive survey design approach. The primary source of data was the administration of questionnaire. A total population of 253 selected staff of the study organizations. The study made use of the whole population due to small size. Two hundred and twenty-four (224) staff returned the questionnaire and accurately filled. Data was presented and analyzed by mean score and standard deviation using Sprint Likert Scale. The hypotheses were analyzed using Z – test statistic tool. The findings indicated that Technological advancements had significant positive relationship with operational efficiency $Z(9.235, P. <.05)$ and Payment selection had significant positive relationship with reduced costs of pharmaceutical firms in Enugu State $Z(10.755, P. <.05)$.

Abiakwe et al (2025) conducted a study on Supply Chain Integration (SCI) and Performance of Pharmaceutical Manufacturing Firms in Enugu State. The study used the descriptive survey design approach. The primary source of data was the administration of questionnaire. A total population of 817 employees of the study organizations. The adequate sample size of three hundred and two (261) using Freund and William's statistic formula at 5 percent margin of error. Two hundred and forty-seven (247) staff returned the questionnaire and accurately filled. Data was presented and analyzed by mean score and standard deviation using Sprint Likert Scale. The hypotheses were analyzed using Z – test statistic tool. The findings indicated that Technology integration had significant positive relationship with real-time communication, $Z(9.672, P.<.05)$. Customer integration had significant positive relationship with product availability of pharmaceutical manufacturing firms in Enugu State, $Z(12.063, P.<.05)$.

Ude (2025) conducted a study on Technological Capability and Competitiveness of Pharmaceutical Manufacturing Companies in South-South, Nigeria. Employing a cross-sectional survey design, data was collected from 50 senior managers across 10 registered pharmaceutical companies in the region. The research focused on three dimensions of competitiveness: market share, cost leadership, and innovativeness. The findings reveal a significant and positive

relationship between technological capability and each measure of competitiveness. Specifically, Spearman's rank-order correlation indicated a strong positive correlation between technological capability and both market share and innovativeness, as well as a moderate positive correlation with cost leadership.

Technology integration and cost reduction

Waribugo & Ndukauba (2021) carried out a research work on Information Technology Adoption and Operational Performance of Small and Medium Enterprises in Rivers State, Nigeria. Three hypotheses were tested with the Partial Least Squares-Structural Equation Modeling (PLS-SEM), with the aid of SmartPLS 3.2.6, while ordinal regression was used to determine the combined effect of the exogenous variables on the endogenous variable. Results indicated that Information Technology Adoption promotes Operational Performance, wherein information technology infrastructure and technology alignment moderately amplify operational performance, while individual learning had a weak effect.

Ene & Ajibo (2023) in a study examined Covid-19 Recovery and Growth: Promoting Technology Innovation in Healthcare Sector on Hygiene and Safe Medication Practices in Low-Resourced Nigerian Societies, Data was sourced from mixed research method. Questionnaires, focus group discussions, and in-depth interviews were used to deduce data from 142 healthcare providers, users, and social workers. Participants were randomly selected from three healthcare institutions in Nsukka, Enugu state. Findings revealed that although greater positive perception (66.7%) holds on promoting innovative technology in the healthcare sector; concerns on negative perceptions (33.3%) were; the choice of medication, cultural health behavior and non-adherence to health guidelines. Major factors militating against innovative technology in healthcare sector were corruption in healthcare system, patients' economic level and poor healthcare delivery. Findings depict that age ($\chi^2_{cal} = 84.0$, $p = 0.000 < 0.05$) and income ($\chi^2_{cal} = 53.7$, $p = 0.000 < 0.05$) of patients were found to be significant in the utilization of innovative technology in healthcare.

Iherobiem & Sanusi (2023) conducted a study on Process Innovation as a Strategic Tool in Enhancing the Performance of Organizations: A Study of Manufacturing Firms in Nigeria. The study employed a descriptive survey methodology and population of the study consisted 7,533 employees from specifically 3 chosen manufacturing companies in Nigeria: Lafarge Africa Plc, Flour Mill Nigeria PLC and PZ Cussons. The sample size for the study was estimated using Andrew Fisher's Formula to be 366 and the distributed questionnaire was designed on a five-point Likert scale. Out of the 366 questionnaires that were distributed, 340 were returned, giving the study a response rate of 93%. SPSS was used to examine the data that were obtained. The study found a substantial correlation between the two variables and it was determined that process innovation is important for improving organizational performance.

Adeshina & Abu-Saeed (2024) conducted study on Optimizing technologies for pharmaceutical manufacturing in Nigeria post covid-19. Objective: This study evaluated the impact of covid-19 on Pharmaceutical Industries in Nigeria. It also assesses the awareness and adoption of emerging technologies by Pharmaceutical industries in Nigeria post-covid-19. Methods: This descriptive cross-sectional study was conducted among Pharmaceutical Manufacturing Industries in Nigeria using structured electronic questionnaires for data collection using Google Form software. Data obtained were examined and analyzed by SPSS version 22. Analysis was done using descriptive statistics and results were presented in tables and figures. Chi-square analysis was used to determine the association between variables. Results: The results show that covid-19 impacted the Nigerian Pharmaceutical Industry in some areas, especially in sourcing and distributing materials. Only 50% indicated any knowledge of 4.0.

Adesina & Tihamiyu (2025) Empirical Analysis of Cost Management and Profitability of Manufacturing Companies in Nigeria. Cost management plays a crucial role in determining the profitability and sustainability of manufacturing

firms. The purpose of this research is to analyze the relationship between cost management and the bottom line of Nigerian manufacturing firms, namely those producing industrial and consumer goods. This study uses descriptive statistics and panel regression analysis to examine the relationship between cost management variables and profitability indicators, such as Return on Assets (ROA), Return on Equity (ROE), and Net Profit Margin (NPM). The data for the study comes from the annual reports of companies listed on the Nigerian Exchange Group (NGX) from 2014 to 2023. Results show that administrative expenditures, marketing and distribution charges, and excessive production costs all cut into profits.

Summary of Empirical Review

The summary of empirical review on technology management practices and operational efficiency of pharmaceutical manufacturing firms reveals several important gaps. First, most existing studies have focused broadly on manufacturing or industrial sectors without giving adequate attention to the pharmaceutical industry, which operates under stricter regulatory and quality requirements. Second, many prior studies were conducted in developed economies, leaving limited context-specific evidence for developing regions like Enugu State, Nigeria, where infrastructural and technological challenges differ significantly. Third, earlier research often examined technology management practices in isolation, rather than providing an integrated analysis of key dimensions such as technology acquisition and technology integration in relation to operational efficiency indicators like production speed and cost reduction.

Methodology

The study was carried out in the selected list of inspected local pharmaceutical manufacturing facilities in Nigeria (2018-2019) using WHO key elements in South East, Nigeria by National Agency for Food and Drug Administration and Control (NAFDAC). The study used the descriptive survey design approach. The primary source of data was the administration of questionnaire. The population of the study consisted of staff of the selected pharmaceutical manufacturing firms in Southeast Nigeria. The total population for the study was one thousand, one hundred and forty-four (1144). To determine the adequate sample size of 288, the study adopted the Freund and Williams's statistical formula at 5 percent margin of error. 244 staff returned the questionnaire and accurately filled. Data was presented and analyzed by mean score and standard deviation. The hypotheses were analyzed using Z - test statistics tool.

Data Presentation and Analyses

Data Presentation

The relationship between technology acquisition and production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria

Table 4.1.1: Responses on the relationship between technology acquisition and production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria

		5	4	3	2	1	ΣFX	-	SD	Decision
		SA	A	N	DA	SD		X		
1	Technology acquisition enables pharmaceutical manufacturing firms to adopt advanced production equipment, which	625	320	39	22	15	1021			Agree
		125	80	13	11	15	244	4.18	1.127	

	significantly improves production speed in Enugu State, Nigeria.	51.2	32.8	5.3	4.5	6.1	100%			
2	The acquisition of modern technologies helps pharmaceutical firms automate production processes, leading to faster and more efficient drug manufacturing.	610	320	39	38	10	1017			Agree
		122	80	13	19	10	244	4.17	1.100	
		50.0	32.8	5.3	7.8	4.1	100%			
3	Technology acquisition enhances the capacity of pharmaceutical firms to streamline production operations, thereby increasing production speed and meeting market demand promptly.	640	320	39	24	11	1034			Agree
		128	80	13	12	11	244	4.24	1.062	
		52.5	32.8	5.3	4.9	4.5	100%			
4	With improved technological tools and machinery, pharmaceutical manufacturing firms can reduce production delays and enhance the overall speed of manufacturing activities.	640	320	39	24	11	1034			Agree
		128	80	13	12	11	244	4.24	1.062	
		52.5	32.8	5.3	4.9	4.5	100%			
5	The adoption of new technologies supports better process integration in pharmaceutical firms, which positively influences production speed and operational effectiveness.	635	320	39	22	13	1029			Agree
		127	80	13	11	13	244	4.22	1.091	
		52.0	32.8	5.3	4.5	5.3	100%			
Total Grand mean and standard deviation								4.21	1.0884	

Source: Field Survey, 2026

Table 4.1.1, 205 respondents out of 244 representing 84.0 percent agreed that Technology acquisition enables pharmaceutical manufacturing firms to adopt advanced production equipment, which significantly improves production speed in Enugu State, Nigeria with mean score of 4.18 and standard deviation of 1.127. The acquisition of modern technologies helps pharmaceutical firms automate production processes, leading to faster and more efficient drug manufacturing 202 respondents representing 82.8 percent agreed with mean score of 4.17 and standard deviation of 1.100. Technology acquisition enhances the capacity of pharmaceutical firms to streamline production operations, thereby increasing production speed and meeting market demand promptly 208 respondents representing 85.3 percent agreed with mean score of 4.24 and standard deviation of 1.062. With improved technological tools and machinery, pharmaceutical manufacturing firms can reduce production delays and enhance the overall speed of manufacturing activities 208 respondents representing 79.8 percent agreed with mean score of 4.24 and 1.062. The adoption of new technologies supports better process integration in pharmaceutical firms, which positively influences production speed and operational effectiveness 207 respondents representing 84.8 percent agreed with a mean score of 4.22 and standard deviation 1.091.

The relationship between technology integration and cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria

Table 4.2.1.1: Responses on the relationship between technology integration and cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria

		5	4	3	2	1	ΣFX	-	SD	Decision
		SA	A	N	DA	SD		X		
1	Technology integration helps pharmaceutical manufacturing firms streamline production processes, leading to significant cost reduction in Enugu State, Nigeria.	665	320	39	26	5	1055			Agree
		133	80	13	13	5	244	4.32	.946	
		54.5	32.8	5.3	5.3	2.0	100%			
2	The integration of modern technologies improves operational coordination and reduces waste, thereby lowering production costs in pharmaceutical firms.	625	296	39	44	10	1014			Agree
		125	74	13	22	10	244	4.16	1.130	
		51.2	30.3	5.3	9.0	4.1	100%			
3	Technology integration enables automation of routine tasks, which minimizes labor expenses and contributes to cost reduction.	645	296	39	34	11	1025			Agree
		129	74	13	17	11	244	4.20	1.110	
		59.2	30.3	5.3	7.0	4.5	100%			
4	When pharmaceutical firms integrate advanced technological systems, they achieve better resource utilization and reduced operational costs.	600	296	39	50	12	997			Agree
		120	74	13	25	12	244	4.09	1.181	
		49.2	30.3	5.3	10.2	4.9	100%			
5	Effective technology integration enhances efficiency in production and management processes, which ultimately supports cost reduction in pharmaceutical manufacturing firms.	620	296	39	50	8	1013			Agree
		124	74	13	25	8	244	4.15	1.117	
		50.8	30.3	5.3	10.2	3.3	100%			
Total Grand mean and standard deviation								4.184	1.0968	

Source: Field Survey, 2026

Table 4.2.2.1, 206 respondents out of 244 representing 87.3 percent agreed that Technology integration helps pharmaceutical manufacturing firms streamline production processes, leading to significant cost reduction in Enugu State, Nigeria with mean score of 4.32 and standard deviation of .946. The integration of modern technologies improves operational coordination and reduces waste, thereby lowering production costs in pharmaceutical firms 199 respondents representing 81.5 percent agreed with mean score of 4.16 and standard deviation of 1.130. Technology integration enables automation of routine tasks, which minimizes labor expenses and contributes to cost reduction 203 respondents representing 89.5 percent agreed with mean score of 4.20 and standard deviation of 1.110. When pharmaceutical firms integrate advanced technological systems, they achieve better resource

utilization and reduced operational costs 194 respondents representing 79.5 percent agreed with mean score of 4.09 and 1.181. Effective technology integration enhances efficiency in production and management processes, which ultimately supports cost reduction in pharmaceutical manufacturing firms 198 respondents representing 81.1 percent agreed with a mean score of 4.15 and standard deviation 1.117.

Test of Hypotheses

Test of Hypotheses One: Technology acquisition has no relationship with production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria.

One-Sample Kolmogorov-Smirnov Test

	Technology acquisition enables pharmaceutical manufacturing firms to adopt advanced production equipment, which significantly improves production speed in Enugu State, Nigeria.	The acquisition of modern technologies helps pharmaceutical firms automate production processes, leading to faster and more efficient drug manufacturing .	Technology acquisition enhances the capacity of pharmaceutical firms to streamline production operations, thereby increasing production speed and meeting market demand promptly.	With improved technological tools and machinery, pharmaceutical manufacturing firms can reduce production delays and enhance the overall speed of manufacturing activities.	The adoption of new technologies supports better process integration in pharmaceutical firms, which positively influences production speed and operational effectiveness.
N	244	244	244	244	244
Uniform Parameters ^{a,b}	Minimum	1	1	1	1
	Maximum	5	5	5	5
Most Extreme Differences	Absolute	.590	.578	.602	.598
	Positive	.061	.041	.045	.053
	Negative	-.590	-.578	-.602	-.598
Kolmogorov-Smirnov Z	9.219	9.027	9.411	9.411	9.347
Asymp. Sig. (2-tailed)	.000	.000	.000	.000	.000

a. Test distribution is Uniform.

b. Calculated from data.

Decision Rule:

Since the calculated z-value (9.411) > critical z-value (.000) at the 5% significance level, we reject the null hypothesis (H_{01}).

Decision:

Furthermore, comparing the calculated Z- value ranges from 9.027< 9.411 against the critical Z- value of .000 (2-tailed test at 95percent level of confidence) the null hypothesis were rejected. Thus the alternative hypothesis was accepted which states that Technology acquisition had significant positive relationship with production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria.

Test of Hypotheses Two: Technology integration has relationship with cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria

One-Sample Kolmogorov-Smirnov Test

	Technology integration helps pharmaceutical manufacturing firms streamline production processes, leading to significant cost reduction in Enugu State, Nigeria.	The integration of modern technologies improves operational coordination and reduces waste, thereby lowering production costs in pharmaceutical firms.	Technology integration enables automation of routine tasks, which minimizes labor expenses and contributes to cost reduction.	When pharmaceutical firms integrate advanced technological systems, they achieve better resource utilization and reduced operational costs.	Effective technology integration enhances efficiency in production and management processes, which ultimately supports cost reduction in pharmaceutical manufacturing firms.	
N	244	244	244	244	244	
Uniform Parameters ^{a,b}	Minimum	1	1	1	1	
	Maximum	5	5	5	5	
Most Extreme Differences	Absolute	.623	.566	.582	.545	.561
	Positive	.020	.041	.045	.049	.033
	Negative	-.623	-.566	-.582	-.545	-.561
Kolmogorov-Smirnov Z	9.731	8.835	9.091	8.514	8.771	
Asymp. Sig. (2-tailed)	.000	.000	.000	.000	.000	

a. Test distribution is Uniform.

b. Calculated from data.

Decision Rule:

Since the calculated z-value (9.091) > critical z-value (.000) at the 5% significance level, we reject the null hypothesis (H_{01}).

Decision:

Furthermore, comparing the calculated Z- value ranges from $8.514 < 9.091$ against the critical Z- value of .000 (2-tailed test at 95percent level of confidence) the null hypothesis were rejected. Thus the alternative hypothesis was accepted which states that Technology integration had significant positive relationship with cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria

Discussion of Findings

The relationship between technology acquisition and production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria.

From the result of hypotheses one, the calculated Z- value ranges from $9.027 < 9.411$ against the critical Z- value of .000 which implies that Technology acquisition had significant positive relationship with production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria. In support of the result in the literature review, Okoroafor et al (2025) examined the Strategic Outsourcing and Performance of Pharmaceutical Firms in Enugu State. The findings indicated that Technological advancements had significant positive relationship with operational efficiency and Payment selection had significant positive relationship with reduced costs of pharmaceutical firms in Enugu State and Abiakwe et al (2025) conducted a study on Supply Chain Integration (SCI) and Performance of Pharmaceutical Manufacturing Firms In Enugu State. The findings indicated that Technology integration had significant positive relationship with real-time communication and. Customer integration had significant positive relationship with product availability of pharmaceutical manufacturing firms in Enugu State.

The technology integration and cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria.

From the result of hypotheses two, the calculated Z- value ranges from $8.514 < 9.091$ against the critical Z- value of .000 which implies that Technology integration had significant positive relationship with cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria. In support of the result in the literature review, Waribugo & Ndukauba (2021) carried out a research work on Information Technology Adoption and Operational Performance of Small and Medium Enterprises in Rivers State, Nigeria. Results indicated that Information Technology Adoption promotes Operational Performance, wherein information technology infrastructure and technology alignment moderately amplify operational performance, while individual learning had a weak effect and Adeshina & Abu-Saeed (2024) conducted study on Optimizing technologies for pharmaceutical manufacturing in Nigeria post covid-19. Background: The results show that covid-19 impacted the Nigerian Pharmaceutical Industry in some areas, especially in sourcing and distributing materials. Only 50% indicated any knowledge of 4.0. The adopted technologies by companies were not associated with the size of the companies ($p > 0.05$).

Summary of Findings, Conclusion, Recommendation and Contribution to Knowledge

Summary of Findings

- i. Technology acquisition had significant positive relationship with production speed of pharmaceutical Manufacturing Firms in Enugu State, Nigeria, Z (9.411, P. < .05). This implies that the adoption of modern technologies, advanced machinery, and updated production systems enhances operational efficiency, reduces production cycle time, and enables firms to meet market demand more quickly.

- ii. Technology integration had significant positive relationship with cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria, $Z(9.091, P. < .05)$. This indicates that effectively combining and harmonizing existing and new technologies within production and operational processes helps to minimize waste, reduce duplication of tasks, and optimize resource utilization.

Conclusion

The study concluded that technology acquisition and technology integration had significant positive relationship with production speed and cost reduction of pharmaceutical Manufacturing Firms in Enugu State, Nigeria. Technology management practices play a critical role in enhancing the operational efficiency of pharmaceutical manufacturing firms in Enugu State, Nigeria. The study shows that strategic efforts such as technology acquisition and integration significantly improve production speed and reduce operational costs. The underscores that firms that effectively manage and continuously upgrade their technological capabilities are better positioned to optimize processes, minimize inefficiencies, and remain competitive. Therefore, sustained investment in and proper management of technology is essential for achieving improved operational performance in the pharmaceutical sector.

Recommendations

Based on the findings, the following recommendations were proffered:

- i. Pharmaceutical manufacturing firms in Enugu State should prioritize continuous investment in modern and advanced production technologies, as this will enhance automation, streamline production processes, and significantly improve production speed, enabling them to meet market demand more efficiently.
- ii. Pharmaceutical manufacturing firms in Enugu State should focus on effectively integrating their technological systems such as production, inventory, and information management platforms to enhance coordination, eliminate redundancies, and optimize resource utilization, thereby achieving significant cost reduction and improved operational efficiency.

Contribution to Knowledge

The study contributes to knowledge by empirically establishing the significant role of technology management practices in enhancing the operational efficiency of pharmaceutical manufacturing firms in Enugu State, Nigeria. Specifically, it extends existing literature by demonstrating how technology acquisition improves production speed, while technology integration drives cost reduction within the pharmaceutical sector. The study also provides context-specific evidence from a developing economy, thereby bridging the gap in prior studies that largely focused on developed countries. Furthermore, it offers a comprehensive framework that links technology management practices directly to key operational efficiency indicators, serving as a valuable reference for researchers, policymakers, and industry practitioners seeking to improve performance through strategic technology deployment.

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