Assessing the Impact of Digitalization on the Performance of Manufacturing Sector in Nigeria

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ABSTRACT

This study investigates the impact of digitalization on the performance of the manufacturing sector in Nigeria, focusing on key performance indicators such as revenue growth, operational efficiency, and profitability. Given the increasing role of digital technologies in global industrial competitiveness, this research evaluates how Nigerian manufacturers are leveraging digitalization to drive performance. The study adopts an ex-post facto research design, using secondary quantitative data from the audited financial reports of five publicly listed Nigerian manufacturing firms covering the period 2020 to 2024. Panel Least Squares regression was employed to analyze the data. Findings reveal that operational efficiency (OPEF) has a statistically significant and negative coefficient ($\beta = -0.7650$, $p < 0.000$), indicating that improved operational efficiency often enabled by digital tools significantly enhances firm performance. However, revenue growth (RVGR) was statistically insignificant ($\beta = 0.0125$, $p = 0.6748$), suggesting that revenue increases alone do not drive performance without efficient digital integration. The model's high R-squared value of 0.82 confirms strong explanatory power. The study concludes that digitalization enhances operational performance more than just revenue metrics and recommends targeted investment in digital infrastructure, skill development, and government incentives to accelerate digital transformation in the sector for sustainable growth.

Keywords: Digitalization, Manufacturing Sector, Operational Efficiency, Revenue Growth, and Performance

INTRODUCTION

The global manufacturing landscape is undergoing a profound transformation driven by the accelerating wave of digitalization. Digitalization defined as the integration of digital technologies into all areas of business operations has emerged as a central driver of competitiveness, productivity, and innovation across industries (World Economic Forum, 2024). This transformation is particularly significant for developing economies like Nigeria, where the manufacturing sector plays a pivotal role in industrialization, employment generation, and economic growth (National Bureau of Statistics, 2023). However, Nigerian manufacturers operate in a complex environment characterized by infrastructural deficits, regulatory challenges, and volatile market dynamics, necessitating innovative approaches to drive performance and global relevance (Okeagu & Mgbemena, 2023).

Historically, the manufacturing sector has been recognized as a catalyst for economic development, offering substantial contributions to GDP and providing a foundation for sustained industrial growth (Kouser et al., 2012). In countries that have successfully industrialized, manufacturing has served as a platform for technological learning, value addition, and export diversification (UNIDO, 2024). For Nigeria, the sector's potential remains largely untapped, with structural constraints and outdated production methods limiting its competitiveness (Agbeja, Adelalaiu & Olufeni, 2015). In this context, digitalization offers an unprecedented

opportunity to modernize manufacturing processes, enhance operational efficiency, and drive inclusive economic growth.

Emerging digital technologies such as the Internet of Things (IoT), Artificial Intelligence (AI), cloud computing, blockchain, and advanced data analytics are reshaping manufacturing globally (Lu et al., 2020). The concept of "smart factories," a core element of Industry 4.0, leverages these technologies to create interconnected, flexible, and intelligent production systems (Onuoha et al., 2022). In Nigeria, the adoption of smart manufacturing practices remains nascent but is gradually gaining momentum (Ita, 2023). Empirical evidence suggests that firms adopting digital technologies experience improvements in productivity, product quality, supply chain efficiency, and customer satisfaction (Avenyo, 2024; Ugwu, 2023). However, achieving such outcomes in Nigeria requires overcoming significant barriers, including inadequate digital infrastructure, high costs of technology adoption, and shortages of skilled talent (Adebayo & Ojo, 2023).

Moreover, the COVID-19 pandemic has further accelerated the digital shift across industries, with Nigerian manufacturers increasingly exploring e-commerce platforms, digital payment systems, and AI-driven tools to sustain operations and reach new markets (Bello & Usman, 2021). Despite this progress, the digital transformation of Nigeria's manufacturing sector remains uneven, with many small and medium-sized enterprises (SMEs) lagging behind due to financial, infrastructural, and regulatory challenges (Mgbemena et al., 2023).

Given the sector's centrality to Nigeria's economic aspirations and the transformative potential of digitalization, it is imperative to assess how digital technologies are influencing manufacturing performance. This study aims to explore the impact of digitalization on key performance indicators such as operational efficiency, revenue growth, innovation capacity, market reach, and sustainability in Nigeria's manufacturing sector. By identifying the drivers and barriers to digital adoption and examining its tangible effects on firm performance, this research contributes to a deeper understanding of how Nigeria's manufacturers can leverage digitalization to achieve global competitiveness. Furthermore, it offers actionable insights for policymakers, industry stakeholders, and business leaders seeking to foster a digitally-enabled manufacturing ecosystem in Nigeria.

Problem Statement

The manufacturing sector remains a key driver of economic development, contributing significantly to employment generation, value addition, and industrial growth in Nigeria. However, the sector faces persistent challenges such as declining productivity, inefficiencies in production processes, limited global competitiveness, and rising operational costs. As global economies transition into Industry 4.0, digitalization has emerged as a transformative force capable of addressing these challenges and enhancing manufacturing performance. Digital technologies such as cloud computing, artificial intelligence, Internet of Things (IoT), robotics, and big data analytics offer opportunities to optimize manufacturing operations, improve product quality, reduce waste, and enable flexible production systems (Lu et al., 2020).

Despite the growing recognition of digitalization as a catalyst for industrial competitiveness, the adoption and impact of digital technologies within Nigeria's manufacturing sector remain limited and underexplored. Many manufacturing firms, particularly small and medium-sized enterprises (SMEs), struggle with structural barriers such as inadequate access to capital, unreliable power supply, and poor digital infrastructure. Additionally, low digital literacy among the workforce and lack of strategic planning further hinder the effective implementation of digital technologies (Adebayo & Ojo, 2023).

While some firms in Nigeria have made notable strides in embracing digital tools, the extent to which these technologies influence key performance outcomes—such as operational efficiency, cost reduction, market responsiveness, and profitability—remains largely undocumented. Furthermore, there is a lack of comprehensive empirical evidence to guide policymakers and industry stakeholders in formulating supportive interventions for digital transformation in the manufacturing sector.

Given the global push toward digitalization and the competitive pressures facing Nigerian manufacturers, it is imperative to examine how digital transformation affects their performance and sustainability. This study,

therefore, seeks to fill the existing knowledge gap by assessing the adoption level of digital technologies among manufacturing firms in Nigeria and evaluating their impact on operational and financial performance. The findings will offer valuable insights to inform strategic decisions, policy frameworks, and capacity-building initiatives aimed at accelerating digital transformation and enhancing the global competitiveness of Nigeria's manufacturing industry.

LITERATURE REVIEW

Concept of Digitalization in the Manufacturing Sector

Digitalization in manufacturing refers to the integration of digital technologies into all aspects of production processes, supply chains, and customer interactions. It goes beyond mere digitization (conversion of analog to digital) to fundamentally transform business operations and value creation. Key technologies include Artificial Intelligence (AI), the Internet of Things (IoT), automation, and cloud computing. AI enables predictive maintenance, demand forecasting, and quality control through data-driven insights. IoT connects machines and systems in real-time, facilitating seamless communication across production lines. Automation enhances production efficiency through robotics and advanced control systems, while cloud computing provides scalable infrastructure for storing, analyzing, and sharing operational data (Morrar, Arman & Mousa, 2017).

In the manufacturing sector, these technologies help optimize resource utilization, improve quality control, and foster innovation. For instance, IoT sensors can monitor equipment performance and predict failures, reducing downtime and maintenance costs. Cloud-based platforms enable real-time supply chain visibility, while AI-powered analytics drive product customization and operational agility. As Nigerian manufacturers begin adopting these tools, they can enhance productivity and competitiveness. However, successful digitalization requires not only technology adoption but also organizational change and skill development (Schwab, 2016). Understanding this concept is foundational for assessing its impact on Nigeria's manufacturing sector.

Trends and Drivers of Digital Transformation in Manufacturing

Globally, manufacturing is undergoing a digital revolution. Industry 4.0 technologies, such as AI, IoT, big data, and 3D printing, are transforming traditional manufacturing into smart, connected operations. According to Deloitte (2020), 76% of manufacturers worldwide had adopted or planned to adopt smart factory initiatives by 2021. Key drivers include intensifying global competition, rising consumer demand for customized products, the push for sustainability, and supply chain disruptions caused by events like COVID-19. The pandemic accelerated digital adoption as firms sought to maintain operations remotely, increase agility, and enhance resilience (McKinsey & Company, 2021).

In Nigeria, trends mirror global patterns but progress is uneven. Large manufacturers in sectors like cement, beverages, and FMCG have adopted automation and cloud-based ERP systems to boost efficiency and transparency. Government initiatives like Nigeria's *National Digital Economy Policy and Strategy (2020–2030)* are driving awareness and investment in digitalization. Additionally, the pandemic exposed the vulnerabilities of traditional supply chains, prompting Nigerian firms to digitize processes such as procurement, logistics, and customer engagement (NITDA, 2021). The growing affordability of digital technologies and increased smartphone penetration are further enabling digital transformation, although systemic challenges remain.

Barriers and Challenges to Digitalization in Nigerian Manufacturing

Despite its potential benefits, digitalization in Nigerian manufacturing faces significant barriers. One of the foremost challenges is limited access to financial resources. Many manufacturers, especially SMEs, struggle to afford investments in advanced technologies such as IoT-enabled equipment, robotics, and cloud solutions. A 2022 study by PwC Nigeria found that only 19% of Nigerian manufacturers had a defined digital strategy, largely due to capital constraints. Additionally, infrastructural issues such as unreliable electricity supply and poor internet connectivity hinder the seamless deployment and operation of digital technologies (PwC Nigeria, 2022).

Human capital is another critical challenge. Many Nigerian manufacturers lack employees with the necessary digital skills, such as data analysis, AI programming, and cybersecurity. Moreover, organizational culture often resists change, with traditional hierarchical structures slowing the adoption of agile digital practices. Regulatory uncertainty and insufficient government incentives further compound the problem. While Nigeria's National Digital Economy Policy aims to foster digital transformation, the lack of targeted support for the manufacturing sector means that many firms remain excluded from government-driven digital initiatives (NITDA, 2021). Overcoming these barriers will require coordinated efforts from policymakers, industry leaders, and educational institutions.

Impact of Digitalization on Manufacturing Performance Indicators

Digitalization positively influences key manufacturing performance indicators such as productivity, operational efficiency, innovation, market competitiveness, and profitability. Automated production processes reduce errors and cycle times, increasing throughput and efficiency. IoT-based predictive maintenance minimizes unplanned downtime, while AI-driven quality control enhances product consistency. A study by Accenture (2020) found that manufacturers leveraging Industry 4.0 technologies achieved productivity gains of up to 30% and cost reductions of 15–25%. Additionally, digital supply chain integration improves agility and responsiveness, enabling firms to better meet customer demand (Accenture, 2020).

In the Nigerian context, early adopters of digital technologies are seeing tangible benefits. Large manufacturers like Dangote Group and Nigerian Breweries have reported enhanced operational efficiency and reduced lead times after implementing advanced ERP systems and process automation (PwC Nigeria, 2022). Furthermore, digitalization fosters innovation by enabling mass customization, rapid prototyping through 3D printing, and data-driven product development. It also strengthens market competitiveness by improving customer experience via digital platforms and personalized services. However, the full potential remains underexploited, particularly among SMEs. Broader adoption and deeper integration of digital technologies are essential for driving sustainable growth and global competitiveness in Nigeria's manufacturing sector.

Technology-Organization-Environment (TOE) Theory

The Technology-Organization-Environment (TOE) Theory, developed by Tornatzky and Fleischer (1990), provides a comprehensive theoretical lens for understanding the factors that influence the adoption of digital technologies in manufacturing firms. According to the framework, three critical contexts shape technology adoption decisions: technological, organizational, and environmental. The *technological context* refers to the availability and characteristics of relevant technologies, such as AI, IoT, automation, and cloud computing. The *organizational context* encompasses internal factors like firm size, resources, management support, and digital skills, while the *environmental context* includes external influences such as market competition, regulatory policies, customer demand, and industry trends (Tornatzky & Fleischer, 1990).

In applying the TOE concept to Nigerian manufacturing, it becomes evident that these three contexts interact to influence digitalization outcomes. For instance, infrastructural challenges and limited digital skills (organizational context) impede the adoption of technologies that are technically available (technological context). Similarly, weak regulatory support and fragmented policy implementation (environmental context) further constrain manufacturers' ability to fully leverage digital transformation. Empirical studies affirm the usefulness of the TOE model in developing economies. Oliveira and Martins (2011) found that the framework effectively explained e-business adoption among SMEs in emerging markets, highlighting the importance of aligning internal capabilities with external opportunities. Thus, TOE provides a robust theoretical foundation for assessing how Nigerian manufacturers navigate the complexities of digital transformation, offering insights into both enablers and barriers. It also guides policymakers in designing interventions that address all three dimensions to foster more inclusive and impactful digital adoption.

Empirical Review

Karimu, Mohammed, and Idris (2025) examine the impact of digital transformation on the performance of Small and Medium-sized Enterprises (SMEs) across Lagos, Abuja, and Port Harcourt in Nigeria. Focusing on

the adoption of digital technologies such as cloud computing, artificial intelligence (AI), and big data analytics, the study highlights how these tools are increasingly shaping business operations. Using data collected from 200 SMEs and analyzed through ANOVA in SPSS, the research evaluates the relationship between digital adoption and performance metrics including operational efficiency, revenue growth, and customer engagement. The results reveal that SMEs with high levels of digital adoption experienced a substantial 15% increase in revenue, whereas those with limited adoption saw growth below 5%. Despite the positive impact, several challenges persist, including high implementation costs, insufficient digital skills among entrepreneurs, and poor technological infrastructure, which limit broader digital uptake. The study recommends strategic investments in digital literacy training, improved infrastructure, and financial support to enhance SME digital adoption, fostering sustainable growth and competitive advantage in both local and global markets.

Nwamekwe, Ewuzie, Igbokwe, Chukwuebuka, and Nwabueze (2024) investigate the adoption of smart factories within Nigeria's manufacturing sector, which encompasses industries such as food and beverages, textiles, chemicals, and automotive. The sector faces significant challenges, including outdated infrastructure, limited access to advanced technologies, and a shortage of skilled labor, all of which hinder productivity and growth. Foreign Direct Investment (FDI) remains critical to improving sector performance, yet the transition from traditional manufacturing to smart manufacturing is slow due to multiple obstacles. Early adopters of smart factory technologies report benefits such as improved efficiency and competitiveness but also face challenges like high implementation costs, economic barriers, insufficient infrastructure, regulatory issues, skill deficits, and brain drain. To overcome these challenges, the study recommends strategic measures such as infrastructure development, fostering partnerships with technology firms, government subsidies and grants, promotion of private investment, and enhanced workforce development through targeted training and collaboration with educational institutions. Furthermore, it advocates for policy reforms including supportive regulations and establishment of industry standards to facilitate smart manufacturing adoption. Drawing on successful smart factory implementations globally, the authors suggest initiating pilot projects in Nigeria to showcase the potential benefits. Overall, the adoption of smart factory technologies is projected to significantly enhance Nigeria's manufacturing productivity, operational efficiency, and global competitiveness, thereby positively impacting economic growth.

Kupriyanova, Evdokimova, Soloviova, and Simikova (2023) conducted a comprehensive study to quantify the impact of digitalization on Russia's manufacturing sector using statistical data from regional manufacturers covering output and production factors. By developing advanced mathematical and computer models, the researchers applied dynamic simulation techniques to evaluate the current state of digital adoption and forecast its future benefits. Their analysis revealed that digitalization contributes to a notable increase in productivity and operational efficiency, with potential productivity gains estimated at up to 15% in digitally advanced regions. Moreover, the models allowed for testing different digital transformation scenarios, providing valuable insights for regional and federal authorities to optimize policy and investment decisions. The study underscores the importance of targeted digital interventions in manufacturing to maximize economic returns, guiding strategic planning to enhance competitiveness. These findings emphasize that digital transformation is a critical driver for sustainable growth in the manufacturing industry and can help policymakers prioritize areas for digital infrastructure and technology adoption to stimulate industrial development.

Unegbu, Yawas, and Dan-asabe (2023) investigate the impact of digital transformation on Nigerian Small and Medium-sized Enterprises (SMEs) within the global business environment, emphasizing the critical role of digitalization in enhancing SME competitiveness and operational efficiency. Using a quantitative approach, data collected from a diverse sample of Nigerian SMEs across various industries, business sizes, locations, annual revenues, and years of operation reveal that approximately 65% of these enterprises actively integrate digital tools such as cloud computing, e-commerce platforms, and digital marketing into their operations. The study highlights key benefits, including a 20% increase in operational efficiency, expanded market access, improved innovation capacity, higher customer satisfaction, and cost reductions. Despite these advantages, SMEs face significant challenges, notably financial constraints (reported by 58% of respondents), lack of digital skills (46%), and regulatory hurdles (34%), which impede the full realization of digital transformation benefits. The study confirms a statistically significant positive relationship between digital transformation and SME competitiveness, demonstrating how digital adoption amplifies global market reach, strengthens competitive positioning, fosters international partnerships, and boosts market share and brand visibility. The

findings underscore the indispensable role of digital transformation in driving the growth and global competitiveness of Nigerian SMEs. Consequently, the research provides a foundational framework for policymakers and business leaders to implement targeted strategies and support mechanisms that enhance the digital capabilities of Nigerian SMEs, thereby fostering sustainable growth and resilience in a rapidly digitalizing global economy.

Rotich, Nyiva, and Anyira (2022) examine the influence of digital technologies on the performance of manufacturing firms in Kericho County, Kenya, amid a turbulent and rapidly evolving industrial environment. Automation and other digital innovations are increasingly viewed as critical drivers of sustainable competitive advantage and financial performance. Despite widespread adoption of automation by large Kenyan manufacturers, many firms still face operational challenges, including profit warnings. The study, grounded in Technology Acceptance Theory, employed a descriptive survey design targeting 28 manufacturing firms registered with the Kenya Association of Manufacturers (KAM) as of June 2020. From a population of 4,429 employees, a stratified random sample of 366 respondents was surveyed using structured questionnaires validated by expert judgment and tested for reliability via Cronbach's alpha. Data analysis involved descriptive statistics (frequencies, means, standard deviations) and inferential statistics through multiple regression. Findings revealed that digital technologies had a significant positive effect on firm performance ($\beta = .374$, $p < 0.05$), highlighting their role in improving operational efficiency and competitive positioning. The study concludes that ongoing investment and engagement in digital technologies are essential for Kenyan manufacturing firms to enhance performance and sustain competitive advantage. Consequently, it recommends increased focus on digital transformation initiatives to address existing challenges and leverage technological benefits fully.

RESEARCH METHODOLOGY

Research design

This study employed an ex-post facto research design to investigate the impact of digitalization on the performance of the manufacturing sector in Nigeria. This design is suitable because it examines existing conditions and historical data without manipulating any of the variables, thereby allowing for the assessment of causal relationships based on observed outcomes. The study relied on quantitative secondary data to evaluate how digitalization initiatives have influenced key performance indicators such as revenue growth, operational efficiency, and profitability within the sector. Specifically, the study used revenue growth (annual revenue change), operational efficiency (operating expenses over revenue), and profitability (return on assets) to assess digitalization's impact on manufacturing firms' performance. Data were obtained from the published annual financial statements of five manufacturing companies listed on the Nigerian Stock Exchange (NSE). These firms were selected based on their consistent publication of audited reports, sector relevance, and the availability of digital transformation disclosures. The use of publicly available audited financial data enhances the reliability and objectivity of the analysis. The study covered a five-year period from 2020 to 2024.

Model Specification

The model for specification for the study is presented as;

$Y = \beta_0 + \beta_1 + \beta_2 + \mu$ …….. (1)

$ROA = \beta_0 + \beta_1^{RVGR} + \beta_2^{OPEF} + \mu$ …….. (2)

Where: RVGR = Revenue Growth

OPEF = Operational Efficiency

ROA = Return on Assets

β_0 = Constant

$\beta_1 - \beta_2$ = Coefficients

μ = error term

The Regression Results

Table 1: Summary of Panel Least Squares

Variable	Coefficient	Std. Error	t-Statistic	Prob.
RVGR	0.012516	0.029433	0.425236	0.6748
OPEF	-0.765010	0.085545	-8.942781	0.0000
C	0.745374	0.086177	8.649322	0.0000
R-squared	0.819838	Sum squared resid		0.092019
Adjusted R-squared	0.803459	Log likelihood		34.58455
S.E. of regression	0.064673	F-statistic		50.05611
		Prob(F-statistic)		0.000000

Source: Eviews 9.0

The panel regression results presented in Table 1 examine the impact of digitalization on the performance of the manufacturing sector in Nigeria. The model includes two key independent variables: revenue growth (RVGR) and operational efficiency (OPEF), with company performance as the dependent variable. The coefficient for RVGR (0.0125) is positive but statistically insignificant ($p = 0.6748 > 0.05$), suggesting that changes in revenue growth do not have a significant direct effect on manufacturing performance within the observed period. This could imply that while revenue growth may reflect market expansion, it alone does not capture the transformative effect of digitalization on firm performance.

In contrast, operational efficiency (OPEF) has a negative and highly significant coefficient (-0.7650) with a p-value of 0.0000, indicating that operational inefficiency significantly undermines performance. The negative sign means that as operating expenses increase relative to revenue (i.e., declining efficiency), performance decreases—highlighting that efficient cost management, likely enhanced by digital technologies, is vital for firm success. The constant term (C) is positive and significant, indicating a strong baseline level of performance in the absence of changes in the independent variables. The R-squared value (0.8198) shows that approximately 82% of the variation in performance is explained by the model, confirming a good fit. The Adjusted R-squared (0.8035) further supports model robustness after adjusting for degrees of freedom.

DISCUSSION OF FINDINGS

The regression results reveal that operational efficiency (OPEF) has a statistically significant negative relationship with the performance of manufacturing firms in Nigeria. This finding underscores the critical role digitalization plays in enhancing operational processes. Digital tools such as enterprise resource planning (ERP), artificial intelligence (AI), and industrial Internet of Things (IoT) are known to improve workflow automation, reduce waste, and optimize production cycles (Mgbemena et al., 2023). The result suggests that manufacturing firms that fail to adopt these technologies tend to operate inefficiently, leading to higher costs and reduced performance. Hence, digitalization is not just a technological shift but a strategic imperative for the Nigerian manufacturing sector.

Conversely, revenue growth (RVGR) was found to be statistically insignificant, implying that increases in revenue alone do not guarantee improved firm performance. This outcome aligns with literature suggesting that without effective cost control and digital integration, revenue gains may not translate into profitability or efficiency (Karimu, Ardo & Gurin, 2025). Thus, digitalization must be implemented holistically addressing not just market expansion but internal systems that enhance productivity and quality control.

Furthermore, the significant constant term in the model highlights a strong baseline performance, likely supported by structural factors such as regulatory frameworks or foundational capabilities. However, the

absence of financial significance in revenue growth could be attributed to inadequate reinvestment in digital infrastructure, poor financing access, or lack of digital literacy. According to Unegbu, Yawas, and Dan-Asabe (2023), many Nigerian SMEs and manufacturers struggle with funding their digital transformation due to high capital costs and insufficient digital skills. These findings support the argument that successful digitalization in manufacturing depends not only on the availability of technology but also on access to finance and investment in quality systems.

CONCLUSION

This study has assessed the impact of digitalization on the performance of Nigeria's manufacturing sector using panel regression analysis. The findings reveal that while revenue growth does not significantly influence performance, operational efficiency strongly affected by digital tools has a major impact. This demonstrates that digitalization enhances performance not by merely increasing revenue but by reducing operational bottlenecks and enabling efficient resource utilization.

Inadequate financing and limited technological infrastructure remain major obstacles, reinforcing the view that digital transformation requires a supportive ecosystem, including investment in infrastructure, workforce development, and access to digital financing. Moreover, manufacturers that prioritize automation and smart technologies tend to be more competitive, profitable, and quality-driven in the long run.

RECOMMENDATIONS

i. Manufacturers should prioritize investments in digital tools that enhance operational efficiency.
ii. Government should offer digitalization grants or subsidized loans to support SME transformation.
iii. Training programs must be established to improve digital literacy in the manufacturing workforce.
iv. Policymakers should enforce industry-wide digital adoption standards to enhance competitiveness.

REFERENCE

1. Accenture. (2020). Industry X.0: Realizing Digital Value in Industrial Sectors. PwC Nigeria. (2022). Nigeria's Industrial Manufacturing: Trends and Outlook 2022.
2. Adebayo, T. S., & Ojo, A. A. (2023). Bridging the digital divide: Infrastructure and human capital challenges in Nigeria's industrial sectors. Journal of African Business, 24(2), 205–224. https://doi.org/10.1080/15228916.2022.2127590
3. Avenyo, E. (2024). Digital technology adoption and performance in African manufacturing firms: Evidence from firm-level data. Technovation, 127, 102738. https://doi.org/10.1016/j.technovation.2024.102738
4. Bello, I. A., & Usman, A. (2021). COVID-19 pandemic and digital transformation in the Nigerian manufacturing sector: A survival strategy? African Journal of Economic Policy, 28(1), 66–82.
5. Deloitte. (2020). 2020 Deloitte Global Industry 4.0 Readiness Report. McKinsey & Company. (2021). Digital Manufacturing: The Revolution Will Be Virtualized.
6. Ita, P. O. (2023). Smart manufacturing and Industry 4.0 in Nigeria: Opportunities, challenges, and policy implications. Journal of Manufacturing Technology Management, 34(1), 120–137. https://doi.org/10.1108/JMTM-06-2022-0234
7. Karimu, I., Ardo, M. A., & Gurin, I. M. (2025). Impact of Digital Transformation on the Performance of Small and Medium-Sized Enterprises in Nigeria. International Journal of Current Science, 15(1), 368–389.
8. Karimu, I., Mohammed, A. A., & Idris, M. G. (2025). Impact of digital transformation on the performance of small and medium-sized enterprises in Nigeria. *International Journal of Current Science, 15*(1), 368–389.
9. Kupriyanova, M., Evdokimova, E., Soloviova, I., & Simikova, I. (2023). The impact of digitalization on the manufacturing industry. *E3S Web of Conferences, 431*, 05030. https://doi.org/10.1051/e3sconf/202343105030

10. Lu, Y., Xu, X., & Xu, W. (2020). Adoption of artificial intelligence and digital technologies in manufacturing: A global perspective and policy implications. Technological Forecasting and Social Change, 157, 120094. https://doi.org/10.1016/j.techfore.2020.120094
11. Mgbemena, C. C., & Okeagu, O. (2023). Digitalization and Manufacturing in Africa: Opportunities and Challenges. African Journal of Technology and Innovation, 4(2), 55–67.
12. Mgbemena, C., & Okeagu, M. (2023). Industry 4.0 adoption and performance outcomes among Nigerian SMEs: A strategic perspective. Management Decision, 61(5), 1134–1153. https://doi.org/10.1108/MD-11-2022-1509
13. Morrar, R., Arman, H., & Mousa, S. (2017). The Fourth Industrial Revolution (Industry 4.0): A Social Innovation Perspective. Technology Innovation Management Review, 7(11), 12–20.
14. Schwab, K. (2016). The Fourth Industrial Revolution. World Economic Forum.
15. National Bureau of Statistics. (2023). Nigerian Manufacturing Sector Data Report: Q1 2023. Retrieved from https://www.nigerianstat.gov.ng
16. Nwamekwe, C. O., Ewuzie, N. V., Igbokwe, N. C., Chukwuebuka, M. U.-D., & Nwabueze, C. V. (2024). Adoption of smart factories in Nigeria: Problems, obstacles, remedies and opportunities. *International Journal of Industrial and Production Engineering, 2*(2), 68–82.
17. Oliveira, T., & Martins, M. F. (2011). Literature review of information technology adoption models at firm level. Electronic Journal of Information Systems Evaluation, 14(1), 110-121.
18. Tornatzky, L. G., & Fleischer, M. (1990). The Processes of Technological Innovation. Lexington Books.
19. PwC Nigeria. (2022). Nigeria's Industrial Manufacturing: Trends and Outlook 2022.
20. NITDA. (2021). National Digital Economy Policy and Strategy (2020–2030).
21. Rotich, J. K., Nyiva, M., & Anyira, F. (2022). Influence of digital technologies on performance of manufacturing firms in Kericho County, Kenya. *IOSR Journal of Business and Management (IOSR-JBM), 24*(9), 1–10. https://doi.org/10.9790/487X-2409010110
22. Unegbu, H. C. O., Yawas, D. S., & Dan-asabe, B. (2023). The impact of digital transformation on Nigerian Small and Medium-Sized Enterprises (SMEs) in the global business landscape. *Jurnal Mekanikal, 47*, 66–85.
23. Unegbu, H. C. O., Yawas, D. S., & Dan-asabe, B. (2023). The Impact of Digital Transformation on Nigerian SMEs in the Global Business Landscape. Jurnal Mekanikal, 47, 66–85.
24. World Economic Forum. (2024). The Global Future of Manufacturing and Digital Transformation: 2024 Industry Report. Retrieved from https://www.weforum.org/reports