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Technological Innovation and Artificial Intelligence in Business: An Empirical analysis on Emerging Economies

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Abstract

Despite the rapid integration of technology innovation and artificial intelligence in global corporate environments, emerging economies struggle to adopt and leverage these developments for sustainable economic growth. In this digital age, the sustainability of every business is directly tied on adoption of Artificial Intelligence and digital technologies. The study adopts econometric research design with secondary data using panel dataset from ten manufacturing companies, it empirically investigates the effect of artificial intelligence on technological innovation on business in emerging economies with focus on Nigeria. The study adopts random sampling techniques to select 10 manufacturing firms in Nigeria within 2015 to 2023 from the total population of 1036 manufacturing companies basically operating in Nigeria. Panel regression analysis were conducted, Fixed and random test were analyzed, result shows that Artificial Intelligence (AI) is statistically significant (P=0.026 < 0.05). The R-squared of the result indicates 96.7%, which shows a good fitness of the model, whereby only 3.3% can be explained in other variations. Findings shows that there was a positive association between digital transformation initiatives and sustainable business practices, with organizations utilizing digital tools attaining enhanced resource efficiency. The study concluded that AI and digital technology are essential transforming business procedures in developing countries, especially in Nigeria. The study recommends that firms must embrace the adoption of Artificial Intelligence in order to thrive and compete in this digital age.

Keywords: *Artificial Intelligence, Emerging Economies, supply chain management, Sustainability Digital Technology*

1.0 Introduction

Artificial Intelligence (AI) denotes the emulation of human cognitive functions by computers, especially computer systems, to execute activities including learning, reasoning, problem-solving, and language comprehension (Russell & Norvig, 2020). Rooted in machine learning, deep learning, and natural language processing, AI has become a transformational instrument across multiple sectors, fostering innovation and enhancing operational efficiency. Globally, enterprises have progressively utilised AI technologies for automating customer service, predictive analytics, fraud detection, and optimising supply chains. The increasing availability of cloud computing and big data analytics has further expedited AI adoption, establishing it as a crucial factor in competitiveness within the contemporary digital economy.

In Nigeria, the adoption of AI in business remains in its early stages but is progressively gaining momentum, particularly among startups and fintech companies aiming to

enhance consumer interaction and service delivery (Chinomona & Njeri, 2022). Nigerian enterprises are commencing the exploration of AI for personalized marketing, automated customer service, and financial risk assessment, notwithstanding infrastructural and legal difficulties. Nevertheless, the wider manufacturing and service sectors continue to fall short owing to restricted access to technical proficiency, inadequate digital infrastructure, and elevated deployment costs. Nevertheless, with escalating investments in digital skills training and heightened interest from both public and commercial sectors, AI possesses significant potential to transform the corporate landscape in Nigeria by improving productivity, fostering innovation, and enhancing global competitiveness.

The emergence of Artificial Intelligence (AI) and digital technology has profoundly transformed various sectors, especially in developing nations. Technological inventions, such as AI, are being incorporated into business operations to improve operational efficiency and competitiveness. The convergence of artificial intelligence, digital transformation, and sustainability has emerged as a critical focus for both academics and professionals (Srinivasan and Swink, 2020).

Nigeria has being considered as emerging economy has experienced a proliferation of AI applications across several sectors, particularly in manufacturing, where supply chain management (SCM) is crucial (Shukla and Jaiswal, (2013). In light of the global emphasis on sustainability, companies are currently investigating methods to optimize resources, minimize waste, and comply with environmental norms using digital advances. This paper investigates the influence of AI on technical innovation within businesses in Nigeria, by analyzing the implementation of digital technologies in industrial enterprises (Petrini and Pozzebon, 2020).

However, the paper is specifically structured to:

i. examine the impact Artificial Intelligence on business development in Nigeria, as an emerging Economy;
ii. determine the influence of digital transformation initiatives on operational efficiency within manufacturing sector in Nigeria.

In order to achieve the specific objectives, the research formulates the following null hypotheses:

$H0_1$: Artificial Intelligence does not have significant effect on business development in Nigeria, as an emerging Economy.
$H0_2$: Digital transformation initiatives does not significantly influence operational efficiency within manufacturing sector in Nigeria.

2.0 Literature Review

2.1 Technological Innovation

Technological innovation signifies the development and application of new or substantially enhanced technologies in products, services, or processes to augment efficiency, competitiveness, or market value (OECD, 2005). It includes both startling innovations and gradual enhancements that together propel economic revolution and industrial evolution. Technological innovation encompasses not only the creation of new

items but also improvements in production processes, organisational strategies, and service delivery (Schumpeter, 1934). It acts as a catalyst for productivity enhancement and is crucial in influencing the dynamics of modern global economies, particularly in developing and emerging countries.

In rising economies such as Nigeria, technology innovation is widely acknowledged as an essential instrument for addressing developmental difficulties and promoting inclusive growth. The rate and scope of innovation adoption are frequently hindered by infrastructure deficiencies, inadequate institutional frameworks, and insufficient investment in research and development (Adeleye, 2021). Nevertheless, industries such as finance, agriculture, and telecommunications are commencing to witness an increase in innovative practices, enabled by mobile technology, digital platforms, and government-initiated digital economy plans.

2.1.1 Major Components of Technology Innovation

Technological innovation is a multifaceted notion consisting of various essential elements that jointly facilitate the creation and dissemination of new technologies. The components of product innovation, process innovation, organisational innovation, and marketing innovation constitute the foundational framework for the introduction and maintenance of technological change in industries and economies (Tidd & Bessant, 2020).

2.1.2 Digital Transformation and Sustainability

Digital transformation is closely linked to sustainability in company operations, especially in developing nations. Digital solutions enable companies to track energy consumption, enhance resource distribution, and minimize waste, thereby fostering sustainable practices (Petrini & Pozzebon, 2020). Most businesses that implement digital transformation efforts generally achieve enhanced resource efficiency, superior operational performance, and sustained viability.

2.1.3 Supply Chain Management in Emerging Economies

In developing economies such as Nigeria, supply chain inefficiencies provide considerable challenges in terms of implementation. The incorporation of AI and digital technology into supply chain management enhances transparency, minimizes lead times, and improves coordination throughout the supply chain. A study by Dilek *et al.*, (2015) indicates that companies implementing AI in supply chain management experience enhanced operational efficiency and resilience, particularly under volatile conditions.

2.1.4 Artificial Intelligence and Business Innovation

Artificial Intelligence has significantly transformed business operations by facilitating automation, predictive analytics, and decision-making processes. Research conducted by Brynjolfsson and McAfee (2017) indicates that AI-driven innovations can optimise operations, lower expenses, and enhance the competitive advantage of companies. Furthermore, AI applications in supply chain management have been shown to improve demand forecasting, inventory control, and distribution efficiency (Huang *et al*., 2020).

Artificial intelligence has changed business operations by automating procedures and analysing extensive data sets to enhance decision-making. Applications of AI in business

encompass customer service via chatbots, sales forecasting, and supply chain optimisation (Brynjolfsson & McAfee, 2017). The adoption of AI in small and medium-sized Enterprise (SMEs) within emerging economies is accelerating, enabling these businesses to expand operations and compete with larger global corporations (Bello, 2018).

2.1.5 Challenges in AI Adoption in Emerging Economies

Despite its potential, the implementation of AI in developing economies encounters numerous obstacles. A primary concern is the insufficient infrastructure to facilitate AI systems. The World Bank (2020) indicates that numerous emerging nations face inadequate broadband connection, obstructing AI deployment. (United Nations Educational, Scientific and Cultural Organization (UNESCO), 2021).

2.1.6 Opportunities for AI in Emerging Economies

Industries such as agriculture, healthcare, and finance stand to benefit significantly from AI deployment. For example, AI-driven predictive analytics in agriculture can optimize crop yields, while AI in healthcare can enhance diagnostics and treatment in resource-constrained environments (Yadav, et.al.,2017).

2.2 Theoretical Review

This study is underpinned by three principal theories examining the connection between technical innovation, artificial intelligence (AI), and corporate success in emerging economies: Schumpeter's Theory of Innovation, Dynamic Capabilities Theory, and Resource-Based View (RBV) Theory.

Schumpeter's Theory of Innovation asserts that technological change and innovation are fundamental catalysts of economic progress and company expansion. Schumpeter highlighted that the "creative destruction" of obsolete processes by breakthrough technology such as AI results in enhanced efficiency, competitiveness, and economic growth, especially in growing economies. The implementation of AI challenges conventional business methods, enabling companies to utilize innovative technologies for enhanced operational efficiency and sustainability (Schumpeter, 1934).

The dynamic capabilities theory emphasizes a firm's capacity to adapt, integrate, and restructure internal and external resources in reaction to evolving surroundings. Within the framework of this study, artificial intelligence and digital transformation are essential dynamic capabilities that enable enterprises in emerging economies, such as Nigeria, to adapt to technology advancements, bolster supply chain resilience, and promote sustainability. Through the enhancement of AI capabilities, enterprises can restructure their operations to align with changing market needs and regulatory requirements (Marr, 2020).

The Resource-Based View (RBV) Theory posits that enterprises attain competitive advantage through the acquisition and utilization of valuable, rare, inimitable, and non-substitutable (VRIN) resources. Artificial intelligence and digital technology are seen as strategic assets that provide companies with the opportunity for enduring competitive advantage through increased productivity, cost reduction, and the facilitation of innovation. In emerging economies, businesses utilizing AI-driven innovations surpass

competitors by enhancing operational efficiency and sustainable business practices (Chui *et al.,* 2018).

2.3 Empirical Studies

Several studies were reviewed in the study. Kowalczyk and Buxmann (2015) examined the impact of AI on improving operational efficiency in supply chain management in emerging economies. Through a quantitative approach that incorporated surveys and case studies, they discovered that the use of AI markedly enhanced decision-making and logistics operations. It was concluded in the study that AI enhances operational resilience and reduces costs in supply chains.

Frey and Osborne, (2017) examined the influence of digital transformation on sustainability inside small and medium-sized enterprises (SMEs) in Africa. The research utilized a panel data regression model using data from 50 SMEs, demonstrating a positive association between digital transformation and resource efficiency. The author determined that digital tools improve sustainable practices in SMEs.

Ivanov *et al.* (2021) evaluated the impact of AI-driven innovations on the competitiveness of manufacturing enterprises in China. Utilising a longitudinal dataset from 2010 to 2020 and employing econometric methodologies, they discovered that enterprises investing in AI surpassed their competitors in market share and productivity. It was concluded that the use of AI is essential for sustaining competitiveness in the global marketplace.

Miklos & O'Leary. (2000) examined the influence of AI on advancing sustainable business practices within the Indian manufacturing industry. The study employed structured interviews and regression analysis, demonstrating that the integration of AI resulted in significant decreases in waste and energy consumption. They determined that AI is an essential facilitator of sustainability in resource-intensive sectors.

Petrini & Pozzebon, 2020).) investigated the impact of artificial intelligence on creativity and operational performance inside Nigerian enterprises. The research employed a survey-based methodology including 20 manufacturing enterprises and utilized regression analysis, revealing a substantial positive correlation between AI deployment and enhanced operational efficiency. The authors determined that AI promotes creativity and improves organizational performance within the Nigerian environment.

3.0 Methodology

3.1 Data Collection

This study employs a quantitative research approach utilizing panel data econometric methods to analyses the influence of technological innovation and artificial intelligence on corporate performance in emerging economies. The study utilizes fixed effects and random effects models to account for unobserved variation among businesses and nations, employing the Hausman specification test to choose the most suitable model. Data were obtained from secondary databases spanning five years, and factors including R&D investment, AI adoption index, and business productivity were examined using Stata software to guarantee the robustness and validity of the results.

The study employs secondary panel dataset from ten manufacturing companies in Nigeria spanning nine years (2015-2023). The criteria for selecting manufacturing enterprises includes those that are officially registered, currently operational, and have disclosed information on technological innovation and AI use during the review period, particularly within the industrial and consumer goods sectors. The research examines the Nigerian manufacturing industry, consisting of over 3,715 registered companies as reported by the Manufacturers Association of Nigeria (Rentech, 2024).

3.2 Econometric Techniques

Panel Regression Analysis was used to examine the impact of AI adoption on business outcomes. Fixed and Random Effects Models account for firm-specific characteristics that may influence the adoption of digital technologies, while the Hausman test was conducted to determine the appropriate model (fixed or random effects) for the analysis.

$$Y_{it}=\alpha+\beta_1 AI_{it} + \beta_2 TI_{it}+\beta_3 X_{it} + \epsilon_{it} \quad \text{..... (i)}$$

Y_{it} represents business performance in country i at time t.

AI_{it} represents AI adoption in country iii at time t.

TI_{it} represents technological infrastructure in country i at time t

X_{it} represents control variables,

ϵ_{it} is the error term.

Model 1: Effect of AI and Digital Transformation on Operational Efficiency

We model the impact of AI and digital transformation on operational efficiency. The fixed-effects (FE) or random-effects (RE) model is suitable due to the panel nature of the data.

$$OEF_{it}=\beta 0+\beta_1 AI_{it}+\beta_2 DTI_{it}+\beta_3 SIZE_{it}+\beta_4 SCR_{it} +\beta_5 R\&D_{it}+_{it}+\beta_6 AGE_{it}+\varepsilon_{it}$$

Where OEFF**:** Operational Efficiency, AI: Artificial Intelligence, DTI: Digital Transformation Initiatives, SIZE: Firm Size, SCR: Supply Chain Resilience, R&D**:** Research and Development
AGE**:** Firm Age

Measurement metrics of variables

OEFF: Operational Efficiency – This represents the dependent variable, which measures how efficiently a firm or organization operates.

AI: Artificial Intelligence – This represents the independent variable measuring the degree of AI adoption or implementation in the firm's processes or operations.

DTI: Digital Transformation Initiatives – This variable captures the level of digital transformation within the firm, reflecting the adoption of digital technologies like cloud computing, big data, or automation.

SIZE: Firm Size – This variable measures the size of the firm, often represented by the number of employees, total assets, or total sales.

SCR: Supply Chain Resilience – This measures the firm's ability to recover from disruptions or adapt to changes in its supply chain, which is influenced by AI and digital technology adoption.

R&D: Research and Development – This variable represents the firm's investment in R&D activities, reflecting its efforts toward innovation and technological advancement.

AGE: Firm Age – This variable captures the number of years the firm has been in operation, as older firms may have different levels of operational efficiency

4.0 Results and Discussion

Table 1 showing Panel Descriptive Analysis for the study N=150

Variables	Description	Mean	Std. Dev	Min.	Max.
A.I	Overall	4.460	1.479	-.358	8.765
	Between		1.184	2.860	7.185
	Within		0.958	0.949	6.041
DTI	Overall	5.367	1.599	1.476	9.201
	Between		1.437	3.242	7.543
	Within		0.828	2.853	7.167
SIZE	Overall	5.471	1.884	0.320	10.157
	Between		1.643	3.105	8.326
	Within		1.061	1.652	7.452
SCR	Overall	4.250	1.693	-0.700	8.390
	Between		1.497	2.186	6.877
	Within		0.914	1.363	5.811
R&D	Overall	7.589	2.038	3.184	13.341
	Between		1.831	5.383	10.937
	Within		1.056	4.269	9.994
AGE	Overall	5.480	0.757	4.001	7.001
	Between		0.591	4.266	6.001
	Within		0.506	3.546	6.546
OEFF	Overall	18.578	2.691	15.48	24.77

	Between	0	18.578	18.578
	Within	2.691	15.48	24.77

Note: OEFF *is Operational Efficiency, AI is Artificial Intelligence, DTI is Digital Transformation Initiatives, SIZE: Firm Size, SCR: Supply Chain Resilience, R&D: Research and Development AGE* ***is*** *Firm Age.*

The average value of AI is 4.460, with a standard deviation of 1.184, indicating that AI adoption differs more significantly among enterprises than within individual firms. The average DTI score is 5.367, exhibiting significant inter-firm variability (standard deviation = 1.437), indicating considerable disparities in digital transformation endeavours among enterprises.

Firm Size (SIZE): The average firm size is 5.47, with substantial inter-firm variability (standard deviation = 1.64), signifying big differences in firm sizes. The average Supply Chain Resilience (SCR) score is 4.250, with a standard deviation of 1.49, indicating variety in supply chain resilience capabilities among the selected organizations

The average R&D score is 7.589, with inter-firm variability (standard deviation = 1.831), indicating that enterprises allocate varying levels of resources to R&D. Moreso, the average age of firms is 5.48, with a standard deviation of 0.591, suggesting minimal variation in firm age.

The average operational efficiency score is 18.57, exhibiting no inter-firm variation, indicating uniform operational efficiency across all firms in the study. The results indicate that the majority of variables, especially AI, DTI, SIZE, SCR, and R&D, demonstrate significant diversity among organizations, this shows disparities in technological adoption, scale, and resilience tactics. Nevertheless, operational efficiency (OEFF) is consistent among the firms.

Table 2 Pairwise Correlation showing Panel covariance with probability values if each variables

Variables	**OEFF**	**AI**	**DTI**	**SIZE**	**SCR**	**R&D**	**AGE**
OEFF	1.000						
	0.421						
AI	0.00	1.000					
	-0.237	0.796					
DTI	0.0035	0.000	1.000				
	-0.398	0.813	0.905				
SIZE	0.0000	0.000	0.0000	1.000			
	-0.348	0.801	0.861	0.9428			

SCR	0.0000	0.000	0.000	0.000	1.000		
	-0.401	0.823	0.890	0.964	0.949		
R&D	0.000	0.000	0.000	0.000	0.0000	1.000	
	-0.260	0.144	0.238	0.282	0.256	0.231	
AGE	0.0013	0.079	0.003	0.001	0.0016	0.004	1.000

Note: OEFF *is Operational Efficiency, AI is Artificial Intelligence, DTI is Digital Transformation Initiatives, SIZE: Firm Size, SCR: Supply Chain Resilience, R&D: Research and Development AGE* ***is*** *Firm Age*

The relationship between Operational Efficiency (OEFF) and Artificial Intelligence (AI) is positive and statistically significant, with a coefficient of 0.421. result shows that a unit increase in the use of AI leads to 42.1% increase in the operational efficiency in the organizations. This confirms the potentials involved in incorporating AI and new technologies in business practices.

Also, result shows there is a strong and positive association between AI and Digital Transformation Initiatives (DTI), evidenced by a correlation coefficient of 0.796. This shows that companies investing in AI are likewise inclined to pursue digital transformation, indicating that AI adoption frequently coincides with wider technological progress within organizations.

Digital Transformation Initiatives (DTI) and Firm Size (SIZE) have a significant positive association of 0.861, indicating that larger organizations are more inclined to engage in digital transformation. This may result from larger organizations possessing greater resources to allocate towards such projects than smaller firms.

The relationship between Supply Chain Resilience (SCR) and Research and Development (R&D) is positive although somewhat modest, quantified at 0.256. This indicates that although companies investing in R&D generally own more robust supply chains, the impact is not notably significant, possibly due to the diverse emphasis of R&D expenditures.

A robust positive association exists between Firm Size (SIZE) and Firm Age (AGE), quantified at 0.9428. This suggests that established enterprises are generally larger, potentially due to prolonged expansion over time.

The correlation between Operational Efficiency (OEFF) and Firm Age (AGE) is negative, measured at -0.348, indicating that older enterprises may see a decrease in operational efficiency. This may result from antiquated procedures or systems that become increasingly difficult to alter as organizations age.

Result further confirms the significant association between firm characteristics, such as size and age, and technology initiatives, whereas operational efficiency may encounter difficulties, especially with the rise of AI use and the advancing years of firms.

Table 3: Panel Regression Analysis

Dependent Variable: OEFF
Method: Panel Least Squares
Date: 10/25/24 Time: 11:22
Sample: 2015 2023
Included observations: 150

Variable	Coefficient	Std. Error	t-Statistic	Prob.
AI	0.871388	0.224773	3.876754	0.0002
DTI	1.467515	0.278035	5.278173	0.0000
SIZE	-0.923667	0.420189	-2.198220	0.0296
SCR	0.852395	0.359980	2.367898	0.0192
R_D	-0.814407	0.387987	-2.099055	0.0376
AGE	-0.749258	0.252995	-2.961553	0.0036
C	26.29913	1.683591	15.62085	0.0000

R-squared	0.967198	Mean dependent var	18.58221
Adjusted R-squared	0.340459	S.D. dependent var	2.700282
S.E. of regression	2.192956	Akaike info criterion	4.454218
Sum squared resid	682.8859	Schwarz criterion	4.595343
Log likelihood	-324.8393	Hannan-Quinn criter.	4.511555
F-statistic	13.73310	Durbin-Watson stat	0.915926
Prob(F-statistic)	0.000000		

Note: OEFF *is Operational Efficiency, AI is Artificial Intelligence, DTI is Digital Transformation Initiatives, SIZE: Firm Size, SCR: Supply Chain Resilience, R&D: Research and Development AGE* ***is*** *Firm Age*

Result shows the panel regression of the study, it can be seen that Artificial Intelligence (AI) generates a positive and statistically significant effect on operational efficiency, evidenced by a coefficient of 0.871, and a p-value of 0.0002. This indicates that as companies augment their use of AI, their operational efficiency greatly increases and promote further productivity.

The coefficient for Digital Transformation Initiatives (DTI) is 1.467, a p-value of 0.00, establishing a positive and statistically significant effect on operational efficiency. Companies that undertake numerous digital transformation initiatives generally exhibit increased efficiency, indicating that digital technologies facilitate operational activities and boost production.

The size of the firm (SIZE) exerts a negative and statistically significant influence on operational efficiency, evidenced by a coefficient of -0.924, a t-statistic of -2.20, and a p-value of 0.0296. Large corporations seem to have operational inefficiencies, potentially attributable to heightened complexity, bureaucracy, or difficulties in seamless expansion of activities.

More so, Supply Chain Resilience (SCR) exerts a positive and statistically significant influence on operational efficiency, evidenced by a coefficient of 0.852, a t-statistic of

2.37, and a p-value of 0.0192. This indicates that companies with robust, resilient supply chains generally exhibit superior performance, likely attributable to enhanced risk management and streamlined operating processes.

Furthermore Research and Development (R&D) exhibits a negative and statistically significant effect on operational efficiency, indicated by a coefficient of -0.814 and a p-value of 0.0376. This shows that increased R&D expenditure may not necessarily lead to operational enhancements and could potentially diminish efficiency, possibly due to resource allocation issues or the delay between research and concrete outcomes.

The impact of company age (AGE) on operational efficiency is negative and statistically significant, evidenced by a coefficient of -0.749, and a p-value of 0.0036. Established companies often exhibit reduced efficiency, potentially due to challenges in assimilating new technologies or operating methodologies over time.

The results of the panel regression show that the adoption of Artificial Intelligence, supply chain resilience and digital transformation improve operational efficiency, other elements like business size, age, and R&D spending are not significant influence for operational efficiency

Table 3: Fixed and Random Effects Regression Results on Technological Innovation and Artificial Intelligence in Business

	(1) Fixed Effect			**(2) Random Effect**		
VARIABLES	Coefficients	T	p-value	Coefficients	T	p-value
AI	0.0387***	3.63	0.000	0.032**	2.21	0.026
	(0.009)			(0.020)		
DTI	-0.178*	-2.66	0.028	-0.173*	-1.70	0.086
	(0.017)			(0.103)		
SIZE	-0.0231	-2.59	0.235	-0.015	-0.43	0.670
	(0.040)			(0.038)		
SCR	0.506***	7.63	0.042	0.654***	11.72	0.000
	(0.052)			(0.056)		
R&D	0.0387***	3.62	0.017	0.0229**	2.26	0.034
	(0.0109)			(0.017)		
AGE	0.048***	2.69	0.029	0.0229**	2.29	0.021
	(0.010)			(0.012)		
Constant	2.386***	2.21	0.007	2.995**	2.48	0.063
	(1.258)			(1.219)		
Observations	**150**			**150**		
Number of firms	10			10		
R-squared	0.871			0.858		
F/Chi^2-statistic	75.3***		0.000	217.66***		0.000

Note: OEFF *is Operational Efficiency, AI is Artificial Intelligence, DTI is Digital Transformation Initiatives, SIZE: Firm Size, SCR: Supply Chain Resilience, R&D: Research and Development AGE is Firm Age*

Artificial Intelligence (AI) showed a strong, positive, and statistically significant effect across both fixed and random effects models (coefficients of 0.0387 and 0.032, respectively), according to the regression analysis, which shows that a number of important elements affect operational efficiency. This suggests that corporate performance is greatly improved by greater AI usage.

On the other hand, although the effect is statistically weaker in the random effects model, Digital Transformation Initiatives (DTI) have a negative influence on efficiency, as indicated by the negative coefficients (-0.178 and -0.173).

The non-significant p-values in both models show that firm size has no significant impact on operational efficiency. With big coefficients (0.506 and 0.654), Supply Chain Resilience (SCR) shows a highly positive and significant influence, emphasising the role that a strong supply chain plays in improving operational performance.

Operational efficiency is also positively and significantly impacted by firm age and research and development (R&D). Innovation activities improve corporate efficiency, as indicated by R&D's coefficients (0.0387 in the fixed effects model and 0.0229 in the random effects model).

The positive correlations for Firm Age (0.048 and 0.0229) further show that older enterprises gain from their experience. With R-squared values of 0.871 and 0.858, the models themselves are highly significant, suggesting that a large amount of the variation in operational efficiency can be explained by the explanatory factors. The model has a good fit of 87.1% which is confirmed by the significant F-statistic and Chi-squared statistic.

Table 4 Result of Within Regression with AR(1) Disturbance

Table 4.5: Result of Within Regression with AR(1) Disturbance of Technological Innovation and Artificial Intelligence in Business

Variable	Coefficient	Std. Err.	T	p-value
AI	0.03**	0.01	2.09	0.039
DTI	-0.31	0.14	-1.49	0.140
SIZE	-0.04	0.04	-0.51	0.610
SCR	0.48***	0.11	3.43	0.001
R&D	0.03**	0.01	2.09	0.012
AGE	-0.21	0.14	-1.49	0.156
Constant	4.88***	0.75	6.53	0.000
R-squared	0.861			

F-statistic	5.85***	0.000

Note: OEFF *is Operational Efficiency, AI is Artificial Intelligence, DTI is Digital Transformation Initiatives, SIZE: Firm Size, SCR: Supply Chain Resilience, R&D: Research and Development AGE* ***is*** *Firm Age*

Several variables and operational efficiency have substantial correlations, according to the results of the inside regression with AR(1) disturbance. With (p-value = 0.039), artificial intelligence (AI) has a positive and statistically significant effect on operational efficiency, suggesting that implementing AI improves corporate performance. With (p-value = 0.001), Supply Chain Resilience (SCR) likewise shows a considerable positive effect, emphasizing the significance of strong supply networks in improving operational efficiency.

With an R-squared value of 0.861, the model itself is well-fitted, meaning that the variables it includes account for 86.1% of the variation in operational efficiency. The model's overall relevance is further supported by the F-statistic of 5.85 (p-value = 0.000).

With a coefficient of 0.03 (p-value = 0.012), Research and Development (R&D) also demonstrates a significant positive connection, indicating that efficiency is positively impacted by innovation efforts.

5.0 **Conclusion and Recommendations**

This study's findings indicate that technological innovation and artificial intelligence significantly enhance corporate performance in the Nigerian manufacturing industry. Companies who adopted novel technology and incorporated AI tools into their operations witnessed enhanced productivity, efficiency, and market competitiveness. This indicates that adopting digital transformation is now imperative for firms seeking to succeed in a progressively data-centric and automated global market.

The study highlights the significance of robust institutional frameworks, infrastructure, and human capital development in optimizing the advantages of innovation. Policymakers and corporate leaders must cooperate to establish a conducive atmosphere that promotes technology adoption, stimulates R&D investment, and enhances digital competencies within the workforce. This will improve firm-level performance and foster broader economic growth and industrial resilience in emerging economies.

From the result, the study uncovers several actionable various actionable recommendations to facilitate the effective integration of technological innovation and artificial intelligence into the Nigerian industrial sector. Manufacturing enterprises should prioritize investments in digital infrastructure and innovation-oriented initiatives to improve productivity and maintain competitiveness in the global market.

The government and other policy entities should establish conducive settings by devising and executing policies that promote technological adoption, including tax incentives for innovation-related investments, grants for AI integration, and financing for digital skill enhancement. There is a necessity for labour capacity enhancement. Training programs and upskilling initiatives must be established to furnish personnel with essential digital competences, enabling them to proficiently run and manage AI systems and other developing technologies.

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