IMPACT OF ARTIFICIAL INTELLIGENCE SYSTEM PRACTICES IN ENHANCING ENTREPRENEURSHIP DEVELOPMENT AND SUSTAINABILITY IN A PHARMACEUTICAL COMPANY, ILORIN

BY

Aremu Moriam Adeyemi[1], AbdulRaheem Oseni Jiddah[2] & Amuzat AbdulAkeem[3]
[1]Dean, Faculty of Management Sciences, Al-Hikmah University, Ilorin, Nigeria
[2]Entrepreneurship Development Centre, Kwara State Polytechnic, Ilorin, Nigeria
[3]Kwara State Civil Services, Procurement Officer
Email: moriam1@alhikmah.edu.ng | abdulraheemo.jiddah@kwarastatepolytechnic.edu.ng | abdulakeemcare@gmal.com

Abstract

This study explored the impact of Artificial Intelligence (AI) on entrepreneurial development and sustainability in Tuyil Pharmaceutical Company, Ilorin, Kwara State. Despite growing global adoption, many pharmaceutical SMEs underutilize AI's potential. The descriptive survey was adopted, and Solow-Swan growth theory, data were collected from 208 staff across five departments using a validated Likert-scale questionnaire. Analysis using MANOVA showed that a 1% variation in AI tools, such as industrial IoT, transport management systems, and robotics, resulted in a 95.7% increase in business expansion. Additionally, 93.7% of sustainable goal achievement and 92.3% of operational efficiency were linked to AI-driven customer analytics and data-based decision-making. The findings suggest that effective integration of AI significantly improves productivity, sustainability, and long-term entrepreneurial success. The study recommends that pharmaceutical firms begin piloting AI applications, especially in robotics and IoT, to enhance safety, optimize operations, and support sustainable development.

Keywords: Artificial Intelligence, pharmaceutical, and sustainability.

Introduction

Entrepreneurship has traditionally revolved around skill-building, networks, and business acumen. However, recent developments show an expanded focus encompassing intrapreneurship and social entrepreneurship. Innovation, economic growth, and job creation remain at the core of entrepreneurship, and the OECD highlights a paradigm shift towards sustainability, ethics, and inclusive access. This change is bolstered by digital tools and financial democratization that lower entry barriers for diverse entrepreneurs. Artificial Intelligence (AI) has become an integral part of this shift. It enhances business operations across multiple domains by integrating machine learning, automation, data analytics, and intelligent customer engagement systems. Zhao and Zhao (2023) stress AI's importance in customer satisfaction, process improvement, and market positioning for SMEs and startups. The financial sector benefits from AI through improvements in risk management, fraud detection, and personalized services. Similarly, AI enables retailers to understand customers better, manage inventory, and drive targeted marketing (Nguyen & Brown, 2023). In manufacturing, AI facilitates supply chain automation, predictive maintenance, and real-time optimization, while in transportation, it enables autonomous navigation and dynamic routing.

In healthcare, AI is a cornerstone of progress. Diagnostic accuracy, drug discovery, and administrative efficiency are improved through AI applications, which facilitate medical imaging analysis, disease prediction, and decision-making support (Topol, 2019). AI also supports pharmacovigilance, helping detect adverse effects through social media and health records monitoring. Jones and Ahmad (2023) highlight how AI accelerates drug discovery by

predicting compound interactions and reducing trial failures. AI thus simultaneously reduces costs and enhances outcomes, offering scalable and sustainable solutions across sectors. Entrepreneurs benefit from AI by using data analytics for demand forecasting, understanding customer preferences, and tailoring offerings. These capabilities not only lead to business creation and job generation but also enhance economic competitiveness and resilience. AI contributes to regional development, innovation, and diversification by enabling efficient resource allocation, personalized customer relations, and scalable solutions. Martinez and Li (2022) emphasize that AI's growing presence across industries is a transformative force, influencing operations, strategy, and competitiveness. However, entrepreneurs—especially SMEs—face barriers such as funding limitations, lack of AI literacy, and skepticism regarding long-term impact. Although AI promises sustainability through optimized operations and resource efficiency, Wang et al. (2021) point to the dearth of frameworks for integrating AI into entrepreneurial ecosystems sustainably. Nguyen and Choi (2021) similarly identify gaps in knowledge concerning AI's role in fostering new business models under rapid technological and market shifts.

Statement of the Problem

Amid regulatory pressures and innovation demands, this study examines how AI supports entrepreneurial development and sustainability in Tuyil Pharmaceutical Company, addressing its roles, applications, and adoption challenges within the Nigerian SME pharmaceutical context.

Research Hypotheses

Ho1: There is no significant influence of the perceived roles of AI practices on entrepreneurial development and sustainability in the Pharmaceutical Company.
Ho_2: There is no significant impact of the practical application of AI practices on entrepreneurial development and sustainability in the Pharmaceutical Company.

Literature Review

Artificial System Practices in the Service Industry

Artificial system practices involve embedding computer-based technologies into business models to enable transformative change (Maheshwari, 2019). These practices foster innovation and competitiveness through digital connectivity and integration.

Robotics Engineering

In the Fourth Industrial Revolution, robotics enables multitasking and human-technology integration. They play vital roles in the courier and service industries by collaborating with humans (cobots), operating autonomously, and handling logistics (Vaisi, 2022).

Internet of Things (IoTs)

IoT technology under Industry 4.0 helps track products and communicate instructions in real time, thereby supporting data management and responsiveness in operations (Greengard, 2015). It transforms how companies analyze complex customer datasets by enhancing connectivity and transparency (Lee et al., 2018).

Transport Management Systems (TMS)

TMS platforms centralize logistics planning, monitoring, and optimization. For courier services, they enhance performance analysis and customer satisfaction while accommodating complex global supply chains (TMS, 2022).

Managerial Decision-Making

AI significantly enhances managerial decision-making by increasing speed and accuracy through data-driven insights (Bharadwaj et al., 2019), despite implementation challenges.

Emotional Intelligence (EI)

In customer-facing sectors like pharmaceuticals, EI enables effective interpersonal communication and conflict management, essential for stakeholder engagement (Goleman, 1995).

Efficiency Optimization

AI improves efficiency in drug discovery, clinical trials, and supply chain management (Ekins et al., 2019). These enhancements are crucial for reducing costs and accelerating delivery in pharmaceutical processes.

Entrepreneurship Development

Entrepreneurial growth is shaped by traits like self-efficacy, creativity, and social networks, as well as institutional support and financial access. Experiential learning plays a significant role in opportunity recognition and value creation (Nafukho & El Mansour, 2023).

Organizational Sustainability

Organizational sustainability emphasizes long-term operational viability and minimal environmental harm. Stakeholders demand that companies adopt green practices and enhance societal value (Dyllick & Hockerts, 2002; Porter & Kramer, 2006).

Theoretical Framework

Solow-Swan Growth Theory

The Solow-Swan model attributes growth to capital, labor, and technology. It suggests that in the long run, technological change—rather than capital investment—is the key driver of economic expansion. Technological innovations enable economies to escape diminishing returns on capital and labor. The theory posits a production function:

$$Y = AF(K, L)$$

Where Y is output, K is capital, L is labor, and A is technology. In recognizing technology's independent role in productivity, the model supports the argument for AI's impact on SME growth and national development. Despite criticisms of its assumptions—such as the possibility of closed economies fostering innovation—the model underpins this study's rationale for technological investment in entrepreneurial development.

Empirical Review

Haabazoka (2019) found a positive link between technological innovation and bank performance in Zambia, particularly in digital banking. Kikiirabo (2023) highlighted that process, service, and organizational innovation significantly improved the Bank of Kigali's performance. Thomas (2014) observed that change management innovations affected employee productivity and customer patronage at Airtel Nigeria. Nguyen et al. (2021) noted digital technologies improved documentation and patient care quality, albeit with workflow disruptions. Doron et al. (2023) explored how generative AI increased R&D efficiency in pharmaceuticals. Latshaw (2023) and S&P Global (2024) noted AI's contribution to biopharma sustainability and speed. McKinsey (2023) illustrated the pharmaceutical sector's shift from AI hype to operational reality, while PwC (2023) outlined how AI reinvented product development.

DataCamp (2023) emphasized AI's role in process efficiency, and Maersk (2024) documented AI's impact on pharmaceutical logistics and sustainability. GlobalData (2023) linked AI with novel medical innovations, while BioPhy (2023) examined AI in drug delivery and pharmacokinetics. African Union (2023) connected AI to sustainable youth development, with implications for pharmaceutical training and innovation. Austin Publishing (2023) and Zap Journals (2023) studied AI's role in enhancing small business performance and green HRM in Nigeria. Pharmaceutical Executive (2023) and African Scholar (2023) showed AI's potential in reducing costs and boosting innovation in drug discovery. Wikipedia (2024), though generalist, offers foundational insights into AI's broad applicability. The Financial Times (2025) highlighted the UK's R&D investment challenges, while TIME (2025) linked AI to sustainable, collaborative innovation.

Methodology

The study used a descriptive survey design, sampling 208 out of 436 workers from Tuyil Pharmaceutical in Ilorin through stratified random sampling. Data were collected using a structured questionnaire covering demographics, AI systems, applications, managerial practices, entrepreneurship development, and organizational sustainability. The instrument showed high reliability (r = 0.981) using split-half Pearson's correlation. Mean and standard deviation were used to analyze research questions, and multivariate ANOVA tested hypotheses at the 0.05 significance level. The research instrument had a Cronbach"s Alpha of 0.89, which is higher than 0.70. Hence, this instrument had good reliability. Therefore, the rule of thumb is that acceptable alpha should be at least 0.70 or above (Hall, 2019).

Table 1: Reliability Analysis

Scale	**Cronbach's Alpha**	**Number of Items**	**Reliability**
Artificial Intelligence System	0.844	**7**	Reliable
AI Application & Managerial Practices	0.823	**3**	Reliable
Entrepreneurship & Sustainability Development	0.730	**6**	Reliable
Total	0.981	16	Reliable

Source: Survey Data (2025)

Model Specification

The multiple regressions below were used to specify the quantitative relationship between the variables of the study.
$Y=B_0+B_1X_1+B_2X_2+B_3X_3+e$ Equation: 1
Where:

Y = Entrepreneurship Development & Organizational Sustainability
B_0 = Constant (intercept)
Bn = Coefficients of the independent variables (n=1,2,3n = 1, 2, 3n=1,2,3)
X_1 = IoTs (Industrial Internet of Things)
X_2 = TMS (Transport Management System)
X_3 = RBT-e (Robotic Engineering)
e = Error term (unexplained variation)
$ENT=B_0+B_1(IoTs)+B_2(TMS)+B_3(RBT\text{-}e)+e$

Y= B0+B1+X1+B2X2+B3X3+e Equation: 2
Where

Y = Combined effect of AI application and managerial practices on entrepreneurship development & sustainability (sum of contributing indicators)
$_{B0}$ = Constant (intercept)
$_{Bn}$ = Coefficients of the independent variables ($n=_{1,2,3n}= _{1,\ 2,\ 3n}=_{1,2,3}$)
$_{X1}$ = Biz-D (Business Decision)
$_{X2}$ = Cus-B (Customer Behavior)
$_{X3}$ = Opt-E (Optimization and Efficiency)
e = Error term (unexplained variation)

All 208 sampled workers, representing 47.7% of Tuyil Pharmaceutical Company's population, participated in the study, with majority from production (50.5%), followed by transport and distribution (28.8%), quality control (8.2%), administration (6.7%), and technical teams (5.8%), reflecting a high response rate due to supportive staff and a flexible work environment.

Table 1:

Descriptive Statistics Show Perceptions of Respondents on the Nexus between Artificial Intelligence Practices and Entrepreneurship and Sustainability Development of Tuyil Pharmaceutical Company, Ilorin

Perception of Respondents on Industrial Internet of Things (IoTs)	N	Mean	Std. Deviation
My company used IOT in tracking customer products	208	3.788	1.4051
My company provides remote access commands that help customer get real-time updates about their products	208	3.707	1.5403
Perception of Respondents on Transport Management System	N	Mean	Std. Deviation
My company was able to use AI for smart supply chain management	208	3.500	1.4005
AI assists my company in meeting customer expectations	208	3.322	1.1577
AI provides insight into firm shipment performance	208	3.500	1.1421
Perception of Respondents on Robotic Engineering	N	Mean	Std Deviation

The use of robotic prevents employees from being exposed to hazards	208	3.351	1.2842
Application of robotic engineering facilitates speed, quality, and operation efficiency	208	3.346	1.3568
Perception of Respondents on Managerial Decision	N	Mean	Std. Deviation
AI enhances manager decision-making	208	3.2692	1.38822
AI enhances the emotional intelligence of managers to streamline operations and improve efficiency	208	3.4904	1.30028
Perception of Respondents on Entrepreneurship Development	N	Mean	Std. Deviation
My company enjoys the expansion of its business over time	208	3.9038	1.18786
My company's productivity increases over time	208	3.409	1.2555
My company offers quality products in large quantities for customer satisfaction	208	3.639	1.5068
Perception of Respondents on Organizational Sustainability	N	Mean	Std. Deviation
My organization was able to survive fierce competition	208	3.433	1.4531
My organization was able to sustain operational improvement over time	208	3.288	1.5207
Employees were able to achieve the target goals in this organization	208	3.534	1.4542
Valid N (listwise)	208		

Source: Norman H. Nie Computation, 2025

Table 1 reveals that respondents affirmed the significant role of artificial intelligence practices in enhancing entrepreneurship development and sustainability at Tuyil Pharmaceutical Company, as all responses surpassed the 2.5 mean threshold on a five-point Likert scale. This finding contradicts Igbara et al. (2015), who argue that small-scale businesses often exhibit poor financial management practices

Table 2:

Multivariate ANOVA Tests Between-Subjects Effects of Artificial Intelligence System on Entrepreneurship Development and Organizational Sustainability

Source	Dependent Variables	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	Employees were able to achieve the target goals in this organization	193.996[a]	3	64.665	937.174	.000
	My company enjoys the expansion of its business over time	198.034[b]	3	66.011	959.686	.000
Intercept	Employees were able to achieve the target goals in this organization	14.029	1	14.029	202.818	.000
	My company enjoys the expansion of its business over time	12.236	1	12.236	256.574	.000
IoTs	Employees were able to achieve the target goals in this organization	1.804	4	.451	6.520	.000
	My company enjoys the expansion of its business over time	1.130	4	.282	5.922	.000

TMS	Employees were able to achieve the target goals in this organization	21.217	4	5.304	76.683	.000
	My company enjoys the expansion of its business over time	19.039	4	4.760	99.803	.000
RBT_e	Employees were able to achieve the target goals in this organization	11.210	4	2.802	40.516	.000
	My company enjoys the expansion of its business over time	28.636	4	7.159	150.112	.000
Error	Employees were able to achieve the target goals in this organization	13.004	188	.069		
	My company enjoys the expansion of its business over time	8.966	188	.048		
Total	Employees were able to achieve the target goals in this organization	207.000	208			
	My company enjoys the expansion of its business over time	207.000	208			
Corrected Total	Employees were able to achieve the target goals in this organization	207.000	207			
	My company enjoy expansion of business over time	207.000	207			

a. R Squared = .937 (Adjusted R Squared = .931)
b. R Squared = .957 (Adjusted R Squared = .952)
Source: Norman H. Nie Computation, 2025

Table 2 shows that artificial intelligence metrics (IoTs, TMS, and RBT-e) accounted for 95.7% and 93.7% of the variation in company expansion and achievement of organizational goals, respectively, indicating their strong influence on entrepreneurship and sustainability development. The F-values (959.686 and 937.174) exceeding the table values confirm the rejection of the null hypothesis, establishing the significant impact of AI systems on Tuyil Pharmaceutical Company's growth at the 5% level.

Conclusion

The study concluded that AI practices, specifically IoTs, TMS, and RBT-e, significantly enhance entrepreneurship and sustainability at Tuyil Pharmaceutical Company by enabling informed decision-making, customer behavior analysis, and operational efficiency. Overall, AI's strategic application strengthens market expansion and productivity, thereby fostering long-term entrepreneurship development in Ilorin, Kwara State.

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