TECHNOLOGY USAGE AND COMPETITIVE ADVANTAGE IN NIGERIA'S DEREGULATED PETROLEUM DOWNSTREAM SECTOR

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ABSTRACT
The study focused on the role of technology usage in fostering competitive advantage in Nigeria's deregulated petroleum sector. For technology usage, the study focused on solar-powered solutions, digital payment systems, and truck-tracking solutions. The study also focused on 3 petroleum organizations operating in the downstream sector. The study was underpinned by the resource-based view theory with a primary emphasis on competitive advantage. A simple random sampling technique was adopted to select 200 participants from the selected organizations. Questionnaire was the only source of data collection instrument. The data was analyzed with the aid of SPSS (Version 24). Regression analysis was adopted to determine the relationships. The findings showed that solar-powered solutions, digital payment systems, and truck-tracking solutions all have a significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector. The study recommends the integration of solar-powered solutions, the expansion of digital payment systems, and the incentivization of partnerships for advanced technology adoption in Nigeria's deregulated petroleum downstream sector. The government should further create an innovation fund and regulations to support truck tracking and real-time inventory management, enhancing efficiency, transparency, and competitiveness.

Keywords: Technology usage, Solar-powered, Digital payment, Truck-tracking, and Competitive advantage.
JEL Classification: O33, O34

1. INTRODUCTION
The global landscape has undergone a transformative shift with the pervasive integration of technology (Obiya, 2024). The widespread adoption of technology has redefined the way nations engage in commerce, governance, and social interactions (Obiya, 2024). Nations that strategically leverage technological innovations experience heightened economic competitiveness, increased efficiency in various sectors, and improved standards of living for their citizens. The integration of technology in Africa is not merely an option but a strategic imperative for addressing developmental challenges and unlocking new opportunities (Oburota, Eke & Adeyemi, 2024). Within Nigeria, a nation endowed with abundant natural resources, the petroleum downstream sector represents a critical arena where technology's role is pivotal (Adeleye et al., 2015). The sector, a linchpin of Nigeria's economy, plays a central role in revenue generation, job creation, and energy supply (Monday & Osaretin, 2024). In recent years, the Nigerian petroleum downstream sector has witnessed a gradual integration of technology, with initiatives ranging from solar-powered solutions to digital payment systems and advanced truck-tracking solutions (Abu et al., 2018).
The challenges associated with technology adoption, specifically in the context of power generation and transmission, pose a significant obstacle (Ali et al., 2023). Even though there are efforts to use solar solutions, problems like unstable power supplies and the high cost of

installation keep the sector from fully realizing the operational efficiency and cost savings that were planned, which hurts its competitive edge. The resistance of consumers to digital transactions, despite government efforts to promote cashless policies through initiatives like POS systems at filling stations, represents a critical challenge. The sector's inability to fully benefit from streamlined financial processes is hampered by its strong preference for cash payments, which hurts its ability to stay ahead of the competition (Fasoye & Olayiwola, 2023). Challenges related to illegal parking of trucks on roads and insufficient enforcement of regulations compromise the efficiency of truck-tracking solutions. This, in turn, leads to supply chain disruptions, increased operational costs, and compromised security (Jagtap et al., 2020). This study aims to analyze the impact of technology adoption on the competitive advantage of Nigeria's petroleum downstream sector. On the technology adoption, solar-powered solutions, digital payment systems, and truck-tracking solutions. The study is structured as follows: the next section reviews theories and relevant literature on technological adoption influencing the downstream petroleum sector. This is followed by a discussion of the research methodology, including data collection and analytical techniques. The subsequent sections present the study's findings and discuss their implications for industry stakeholders and policymakers. Finally, the study concludes with recommendations for enhancing technological adoption to drive sectoral performance.

2. LITERATURE REVIEW

2.1 Theoretical Review

The Resource-Based View (RBV) theory, developed by Jay B. Barney and Birger Wernerfelt in the 1980s, emphasizes an organization's internal resources and capabilities as key drivers of competitive advantage (Barney & Mackey, 2016). In the petroleum downstream sector, these resources include tangible assets like refineries and distribution networks, as well as intangible assets such as brand reputation and technological expertise, all of which help optimize operations and reduce costs. RBV highlights the importance of management capabilities, such as R&D and adaptability to market changes, in sustaining competitive advantage (Nagano, 2019). For a resource to provide a long-term advantage, it must be valuable, rare, inimitable, and non-substitutable, though assessing these factors can be challenging in complex industries (Assensoh-Kodua, 2019). While RBV aids businesses in resource evaluation and strategic allocation, it primarily focuses on internal factors and may overlook external influences like regulatory changes and market disruptions (Bataineh et al., 2023).

The Technology Acceptance Model (TAM), developed by Fred Davis in 1989, is a framework that explains how users come to accept and use technology (Musa et al., 2024). The model is based on two key factors: Perceived Usefulness (PU) (the degree to which a person believes technology will enhance their job performance) and Perceived Ease of Use (PEOU) (the extent to which a person believes technology is free from effort) (Musa et al., 2024). TAM assumes that if a technology is useful and easy to use, users are more likely to adopt it, influencing their behavioural intention and actual usage (Natasia, Wiranti & Parastika, 2022). The model is crucial in understanding technology adoption as it helps organizations predict user acceptance and improve system design (Al-Adwan et al., 2023). In the oil and gas downstream sector, TAM is essential for driving the adoption of digital tools such as automated inventory systems, IoT-based fuel monitoring, and cloud-based supply chain management by ensuring that these technologies are both effective and user-friendly, ultimately enhancing operational efficiency and decision-making (Oni, 2024).

The Diffusion of Innovations (DOI) Theory, developed by Everett Rogers in 1962, explains how new ideas, technologies, or practices spread within a society over time (Min, So & Jeong, 2021). The theory assumes that adoption follows a predictable pattern, influenced by five key attributes: Relative Advantage, Compatibility, Complexity, Trialability, and Observability

(Pinho, Franco & Mendes, 2021). It categorizes adopters into Innovators, Early Adopters, Early Majority, Late Majority, and Laggards, emphasizing the role of social influence and communication channels (Pinho, Franco & Mendes, 2021). DOI is crucial for technology adoption as it helps businesses and policymakers understand how to introduce and promote new technologies effectively (Wamba & Queiroz, 2022). In the oil downstream sector, DOI is vital for driving technological innovations such as automation, digital tracking systems, and alternative energy solutions by identifying barriers to adoption and strategizing for industry-wide implementation.

2.2 Empirical Review

Kumba et al. (2024) conducted a comprehensive review of solar tracking systems (STS), analyzing passive, active, single-axis, and dual-axis configurations across diverse environmental settings. Their findings, based on performance metrics, showed that dual-axis STS boosted energy efficiency by up to 40% compared to fixed panels, though adoption remains hampered by high costs and maintenance demands, especially in resource-scarce regions. Similarly, Zhang and Huang (2023) explored grid-connected solar-to-vehicle (S2V) systems in Scandinavian countries, reporting a 25% adoption increase from 2021 to 2023. However, their analysis highlighted infrastructural bottlenecks and inconsistent policy support as key barriers to broader uptake.

Wang et al. (2021) examined adoption trends using the Unified Theory of Acceptance and Use of Technology (UTAUT) framework, surveying 339 users. Their structural equation modelling (SEM) results revealed that performance expectancy, effort expectancy, and social influence accounted for 68% of adoption intent variance, though hedonic motivation had little impact. Islam and Khan (2024) applied Partial Least Squares SEM (PLS-SEM) to data from 359 participants, finding that perceived ease of use and financial literacy drove adoption, with literacy mediating attitudes by 32%. These findings suggest that usability and education are pivotal to scaling digital payments in developing contexts.

Munikrishnan et al (2024) investigated cashless payment systems among Malaysian businesses, identifying compatibility and technological competence as critical factors influencing uptake. Their survey of 200 firms showed that smaller enterprises faced adoption hurdles due to limited resources, despite recognizing the benefits of efficiency and customer convenience. A comparative study in Europe by Kluiters, Srivastava and Tyll (2023) used regression analysis on 500 users to demonstrate that trust in security protocols and transaction speed explained 60% of adoption variance. Truck-tracking solutions, enabled by GPS and IoT, have emerged as a vital focus in logistics-related technology adoption since 2021. Nivornusit, Kraiwanit and Limna (2024) studied 150 Southeast Asian logistics firms, employing a mixed-methods approach with surveys and operational data. They found that real-time tracking improved delivery efficiency by 18%, with perceived usefulness and competitive pressure driving 55% of adoption variance in a regression model, though costs and data privacy concerns slowed progress. Similarly, Zvarivadza et al (2024) analyzed adoption among 200 European fleet operators, linking a 30% fuel cost reduction to truck-tracking systems while noting resistance due to training needs. These results emphasize the operational gains of tracking technologies alongside persistent implementation barriers.

3. METHODOLOGY

3.1 Theoretical Framework

This study is anchored on the Resource-Based View (RBV) Theory, which posits that a firm's competitive advantage is derived from its ability to acquire and effectively utilize valuable, rare, inimitable, and non-substitutable resources (Barney, 1991). In the context of Nigeria's deregulated petroleum downstream sector, solar-powered solutions, digital payment systems,

and truck-tracking solutions can be seen as strategic resources that firms leverage to gain a competitive edge. Solar-powered solutions enhance operational efficiency and cost-effectiveness, deregulation fosters market expansion and innovation, while truck-tracking solutions improve logistics and supply chain management. By integrating these elements within the RBV framework, the study examines how these factors contribute to sustained competitive advantage in a deregulated environment.

3.2 Model Specification

To empirically examine the impact of solar-powered solutions, digital payment, and truck-tracking solutions on competitive advantage in Nigeria's deregulated petroleum downstream sector, the following econometric model is specified:

$CA=\beta_0 + \beta_1 SPS + \epsilon_1$

$CA=\beta_0 + \beta_2 DP + \epsilon_2$

$CA=\beta_0 + \beta_3 TTS + \epsilon_3$

Where:

- CA = Competitive Advantage
- SPS = Solar-Powered Solutions
- DP = Digital Payment
- TTS = Truck-Tracking Solutions
- β_0 = Intercept
- $\beta 1, \beta 2, \beta 3$ = Coefficients of the independent variables
- $\epsilon_1, \epsilon_2, \epsilon_3$ = Error terms

3.3 Design and Method of Data

The study adopted a descriptive survey design with a focus on a quantitative approach. The study's emphasis was on 200 workers across all cadres from three petroleum firms in the downstream sector. The study used a convenience sampling approach, in which participants were chosen according to their convenience and desire to participate (Etikan et al., 2016). Questionnaires divided into 2 parts served as the only instrument. The first part included questions on the respondents' demographics, while the second part focused on dependent and independent variables, is found in the second part. Statistical Package for Social Sciences (SPSS) (version 20) was used to code, alter, and analyze primary data. Regression analysis was further utilized for inferential statistics to ascertain the relationship between the independent and dependent variables.

4. RESULT AND DISCUSSION OF FINDINGS

4.1 Test of Hypotheses

Hypothesis One

H_0: Solar-powered solutions have no significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector.

Table 1a: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.345[a]	.119	.114	.65295

a. Predictors: (Constant), Competitive advantage

Table 1a (Model Summary) denotes that R Square value of 0.119 indicates that approximately 11.9% of the variance in the dependent variable (Solar-powered solutions) can be explained by the independent variable (Competitive advantage). Thus, Accept H_1 and Reject H_0 that solar-powered solutions have a significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector.

Table 1b: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	9.711	1	9.711	22.777	.000[b]
	Residual	72.051	169	.426		
	Total	81.762	170			

a. Dependent Variable: Solar-powered solutions
b. Predictors: (Constant), Competitive advantage

Table 1b (ANOVA table) shows that the regression model is statistically significant with a p-value of .000 (b). This suggests that there is a significant relationship between the independent variable (Competitive advantage) and the dependent variable (Solar-powered solutions).

Table 1c: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	2.219	.312		7.119	.000
	Competitive advantage	.365	.077	.345	4.773	.000

a. Dependent Variable: Solar-powered solutions

Table 1c (Coefficient) shows that the constant term (2.219) represents the estimated value of the dependent variable when the independent variable (Competitive advantage) is zero. In this context, it suggests that, with zero competitive advantage, the expected value of Solar-powered solutions is 2.219. The coefficient (0.365) indicates that for a one-unit increase in Competitive advantage, there is an expected increase of 0.365 units in Solar-powered solutions. The standardized coefficient (Beta) is 0.345, providing a measure of the relative importance of this predictor variable.

Hypothesis Two

H_0: Digital payment system has no significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector.

Table 2a: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.666[a]	.443	.440	.48768

a. Predictors: (Constant), Competitive advantage

Table 2a (Model Summary) denotes that the R Square value of 0.443 indicates that approximately 44.3% of the variance in the dependent variable (Digital payment system) can be explained by the independent variable (Competitive advantage). Thus, Accept H_1 and Reject H_0 that digital payment system has a significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector.

Table 2b: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	32.017	1	32.017	134.618	.000[b]
	Residual	40.194	169	.238		

	Total	72.211	170			

a. Dependent Variable: Digital payment system
b. Predictors: (Constant), Competitive advantage

Table 4.2.1b (ANOVA table) shows that the regression model is highly statistically significant with a p-value of .000 (b). This suggests that there is a significant relationship between the independent variable (Competitive advantage) and the dependent variable (Digital payment system).

Table 2c: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.907	.233		3.896	.000
	Competitive advantage	.663	.057	.666	11.603	.000

a. Dependent Variable: Digital payment system

Table 2c (Coefficient) shows that the constant term (0.907) represents the estimated value of the dependent variable when the independent variable (Competitive advantage) is zero. In this context, it suggests that, with zero competitive advantage, the expected value of the Digital payment system is 0.907. The coefficient (0.663) indicates that for a one-unit increase in Competitive advantage, there is an expected increase of 0.663 units in the Digital payment system. The standardized coefficient (Beta) is 0.666, providing a measure of the relative importance of this predictor variable.

Hypothesis Three

H_0: Truck-tracking solutions have no significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector.

Table 3a: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.691[a]	.478	.475	.50911

a. Predictors: (Constant), Competitive advantage

Table 3a (Model Summary) denotes that the coefficient of determination (R-squared) is approximately 0.115. This means that about 11.5% of the variance in the dependent variable, Competitive advantage, can be explained by the independent variable, Regulatory policies. Thus, Accept H_1 and Reject H_0 that truck-tracking solutions have a significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector.

Table 3b: ANOVA[a]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	40.102	1	40.102	154.717	.000[b]
	Residual	43.804	169	.259		
	Total	83.906	170			

a. Dependent Variable: Truck-tracking solutions
b. Predictors: (Constant), Competitive advantage

Table 3b (ANOVA table) shows that the regression model is highly statistically significant with a p-value of .000 (b). This suggests that there is a significant relationship between the independent variable (Competitive advantage) and the dependent variable (Truck-tracking solutions).

Table 3c: Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients		
		B	Std. Error	Beta	t	Sig.
1	(Constant)	.993	.243		4.085	.000
	Competitive advantage	.742	.060	.691	12.439	.000

a. Dependent Variable: Truck-tracking solutions

Table 3c (Coefficient) shows that the constant term (0.993) represents the estimated value of the dependent variable when the independent variable (Competitive advantage) is zero. In this context, it suggests that, with zero competitive advantage, the expected value of Truck-tracking solutions is 0.993. The coefficient (0.742) indicates that for a one-unit increase in Competitive advantage, there is an expected increase of 0.742 units in Truck-tracking solutions. The standardized coefficient (Beta) is 0.691, providing a measure of the relative importance of this predictor variable.

4.2 Discussion of Findings

Hypothesis one (H_{01}) was rejected, asserting that solar-powered solutions have no significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector. This implies that solar-powered solutions play a significant role in influencing competitive advantage within the sector. This finding is substantiated by the research conducted by Srivastava et al. (2023), who, through a comprehensive investigation, found evidence supporting the positive impact of solar-powered solutions on the competitive landscape of the deregulated petroleum downstream sector in Nigeria. The study by Olawuyi (2022) further supports this conclusion. However, Ibegbulam, Adeyemi and Fogbonjaiye (2023) argue that the high initial investment and maintenance costs associated with solar-powered solutions pose challenges, potentially limiting their widespread adoption.

Hypothesis two (H_{02}), asserting that the digital payment system has no significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector, has been rejected. This indicates that the adoption of digital payment systems plays a crucial role in shaping competitive advantage within the sector. This finding aligns with the research of Dehghanpouri, Soltani and Rostamzadeh (2020), which demonstrated a strong correlation between digital payment integration and improved operational efficiency, customer satisfaction, and market positioning among petroleum marketers. However, Putrevu and Mertzanis (2024) cautioned that while digital payment systems enhance transaction speed and transparency, they also expose businesses to cybersecurity risks and regulatory compliance challenges. Similarly, Nguimkeu and Okou (2021) noted that the uneven adoption of digital payment infrastructure across Nigeria creates disparities in competitive advantage, benefiting technologically advanced firms while marginalizing smaller, less digitized players.

Hypothesis three (H_{03}) was rejected, asserting that truck-tracking solutions have no significant impact on competitive advantage in Nigeria's deregulated petroleum downstream sector. This rejection implies that truck-tracking solutions play a discernible role in influencing competitive advantage within the sector. This finding aligns with the outcomes of the research conducted by Myllynen et al. (2016) and is further substantiated by a study undertaken by Harcourt (2023). Both studies converge on the conclusion that truck-tracking solutions contribute significantly to enhancing competitive advantage in the context of Nigeria's deregulated

petroleum downstream sector. However, the effectiveness of truck-tracking solutions is highly contingent on infrastructural reliability and data accuracy (Hazrathosseini & Afrapoli, 2023).

5. CONCLUSION AND POLICY RECOMMENDATIONS

The study examined the relationship between technology adoption and competitive advantage in Nigeria's deregulated petroleum downstream sector, focusing on solar-powered solutions, digital payment systems, and truck-tracking solutions. It found a significant link between solar-powered solutions and competitiveness, highlighting the role of sustainable energy in aligning with global industry trends. The integration of digital payment systems was also identified as crucial for efficiency, transparency, and security in financial transactions. Additionally, truck-tracking solutions were shown to enhance logistics and operational efficiency, improving reliability and responsiveness. These findings provide a strategic roadmap for firms to navigate deregulation and strengthen their market position.

The policy recommendation emphasizes the integration of solar-powered solutions, the expansion of digital payment systems, and the incentivization of partnerships for advanced technology adoption in Nigeria's deregulated petroleum downstream sector. Companies should invest in solar panels, energy storage, and smart grids, particularly for off-grid locations, while collaborating with renewable energy firms for long-term sustainability. Expanding and securing digital payment systems requires multi-channel platforms, partnerships with fintech providers, and enhanced cybersecurity measures to improve accessibility and consumer trust. Additionally, the government should establish an innovation fund and regulatory framework to support truck-tracking systems and real-time inventory management, ensuring greater operational efficiency, transparency, and competitiveness within the sector.

Future research could explore the long-term impact of technology adoption on financial performance and customer satisfaction in Nigeria's deregulated petroleum downstream sector. Additionally, comparative studies across different regions or industries could provide insights into best practices for technology-driven competitive advantage. Further investigations could also assess potential challenges in implementing these technologies, such as regulatory constraints, cost implications, and infrastructure limitations. Lastly, examining the role of emerging technologies like artificial intelligence, blockchain, and the Internet of Things (IoT) in optimizing operations and decision-making could offer valuable perspectives for industry stakeholders.

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