JOSCM Journal of Optimization and Supply Chain Management
Print ISSN:3079-1022 Online ISSN:3079-1030

ICT Integration for Improving Logistics Agility of Petroleum Distribution in Nigeria

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Article Info

Article type:
Research Article

Article history:
Received March 3, 2025
Received in revised form May 5, 2025
Accepted May 20, 2025
Available online June 4, 2025

Keywords:
logistics
agility
petroleum
distribution
ICT and best strategies

ABSTRACT

Objective: This study examines how Information and Communication Technology (ICT) integration enhances logistics agility in the distribution of petroleum products in Nigeria. It investigates the roles of digital tools such as ERP systems, IoT-enabled tracking, big data analytics, and real-time information platforms in strengthening responsiveness, operational flexibility, and distribution performance within the downstream petroleum sector.

Methods: A mixed-methods approach was adopted, using structured questionnaires and interviews administered to 210 executives across seven major oil marketing companies under the Major Oil Marketers Association of Nigeria (MOMAN). A total of 187 valid responses were analyzed using descriptive statistics, regression modelling, and ANOVA to assess the influence of ICT variables on distribution agility. Additional non-parametric tests (K-S) validated data distribution patterns and stakeholder consensus on ICT-driven strategies.

Results: Findings reveal strong agreement on ICT's positive contribution to petroleum distribution efficiency, with mean ratings above 4.4 on a five-point scale across key agility dimensions, namely real-time information flow, cost optimization, demand–supply matching, risk mitigation, and GIS-based monitoring. Regression results show a significant relationship between ICT investment and agile distribution performance. The coefficient indicates that each unit increase in ICT capability yields a 76.6% improvement in agility performance. Stakeholders also strongly support strategic options such as integrated ICT systems, pipeline upgrades, and improved supply capacity.

Conclusion: ICT integration is a critical enabler of agile petroleum distribution in Nigeria, enhancing visibility, accountability, operational speed, and customer value. Strengthened investments in digital infrastructure, workforce capabilities, and coordinated data-driven practices are essential to achieving responsive and competitive downstream logistics.

Cite this article: Ucheobi, C. A., Ejem, E. A., Aikor, S. T., Nze, O.N., Poi, E. L., Nwoko, N. M., Ekejiuba, C. F., Aghanwa, O. A. (2025). ICT Integration for Improving Logistics Agility of Petroleum Distribution in Nigeria. *Journal of Optimization and Supply Chain Management, 2*(2), 95-110. https://doi.org/10.22034/ISS.2025.9406.1050

Publisher: International Scientific Services (ISS).
DOI: https://doi.org/10.22034/ISS.2025.9406.1050

1. Introduction

Nigeria, despite its huge oil resources, has continued to experience intermittent domestic oil supply scarcities. These oil shortages have become a recurring phenomenon, manifesting in regular queues at fuel stations. The causes of these shortages in the nationwide supply and distribution of petroleum products have been attributed to several factors which includes insufficient storage capacity, ineffective distribution network channels, sabotage resulting from pipeline vandalization, lack of accurate consumption statistic records for effective planning, insufficient refinery capacity, use of aging pipeline distribution network and lack of good and reliable logistics facilities and infrastructure (Alaba & Sunday, 2014). Shortage of petroleum products usually gives rise to the activities of black-market operators, otherwise known as the parallel markets, which sprout all over the country and continue to thrive as long as the epidemic scarcity persists. The result of the perennial shortages of petroleum products can be categorized into economic and non-economic costs to the economy, which has contributed negatively by hindering effective national development and economic growth (Izuaka, 2023). It has been identified over time as a major contributing factor in the slow pace of industrialization process and has also significantly contributed to undermining the effort of successive governments in achieving sustainable economic growth, enhanced competitiveness of local industries across domestic, regional, and global markets, and the creation of employment opportunities.

The non-economic costs of petroleum products scarcity include frustrations experienced at fuel stations due to long queues, loss of lives resulting from fuel explosions due to adulterations as well as explosions from fuel dumps at homes as people tend to store these products for future use, loss of lives due to absence of fuel to transport patients to hospitals for treatment or referrals, long treks or long waiting time at bus stops, among others (Ocheni, 2015, Obi, 2022, Ojo, 2022 & Izuaka, 2023). The efficient management of petroleum products supply and distribution in Nigeria requires a well-articulated and strategically structured logistics and supply chain system which must take into consideration the effective collaboration and integration of the major players in network such as petroleum products suppliers, shipping companies and their agents, government agencies involved in products clearance and certification and local distribution companies such as the Independent Petroleum Marketing Association of Nigeria (IPMAN) whose trucking and haulage services are critical to getting the products down to the hinterlands (Itsekor, 2018). Given these identified challenges resulting from inadequate supply and distribution of petroleum products in Nigeria, this research explores the effect of technology on agile logistics and its petroleum products distribution performance in Nigeria with the aim of proffering solutions on how to improve the distribution in a timely and efficient manner to achieve best results.

2. Literature Review

The conceptual framework positions ICT integration as the central independent variable influencing the dependent variable of logistics agility in petroleum product distribution. The independent variable is ICT Integration (Enterprise Resource Planning (ERP), Internet of Things (IoT) and GPS-enabled tracking, Big Data Analytics & Predictive tools, Real-time Communication & Information Sharing Platforms, GIS-based facility and retail outlet monitoring. The mediating agility dimensions are ICT integration enhances logistics agility by improving: effective communication (real-time, accurate data sharing), planning and forecasting (demand–supply matching, risk anticipation), operational responsiveness (product positioning, routing, inventory tracking), cost optimization (transportation, inventory, and resource efficiency) and risk mitigation (reducing uncertainties, theft, and supply disruptions. The dependent variable is logistics agility performance measured by the system's ability to: ensure timely and reliable product availability, improve customer satisfaction (shorter cycle time, better service levels), enhance operational efficiency (reduced losses, improved visibility), strengthen competitiveness in Nigeria's deregulated petroleum market, moderating/contextual factors, infrastructure gaps (aging pipelines, weak depot networks), human resource capacity (skills and ICT literacy), policy/regulatory environment and resistance to technological change

Logistics agility refers to the ability of petroleum supply chains to respond swiftly to market changes, reconfigure operations, and maintain flow continuity under uncertainty (Ucheobi et al., 2024), Eteyen (2024), Tob-Ogu et al. (2018). Petroleum Distribution in Nigeria involves complex, multi-modal transportation and depot systems, which are frequently disrupted by scarcity, fuel theft, bad roads, and regulatory inefficiencies (Terab et al., 2023). The adoption and deployment of digital tools (e.g., GPS, ERP, IoT, AI, cloud systems, blockchain) across logistics operations to facilitate real-time visibility, coordination, and decision-making (Olugbade et al., 2022). Furthermore, Olugbade et al. (2022) emphasize that GPS and ERP tools strengthen real-time reconfiguration capacities. There exist two domains of literature with little mutual influence relating to operational agility: agile development and manufacturing agility. Agile development originated in the domain of software and product design, whereas agile manufacturing emerged within the production environment. Nonetheless, neither field independently offers a complete framework for achieving operational agility outside the confines of software or manufacturing contexts (Lorenz, Bäckert, Heck, & Johannes, 2020). Agile development underscores ongoing customer engagement through feature-driven design, makes use of iterative feedback loops, and requires relatively lighter documentation than conventional methods. Its practices are largely executed by self-directed, cross-functional teams employing incremental and iterative processes. Consequently, research in this area has predominantly focused on how teams function and the effectiveness of associated methods (Lorenz, Bäckert, Heck, & Johannes, 2020).

The notion of capability in strategic management is often described as the organization's ability to reconfigure, integrate, and adapt both internal and external competences, resources, and skills in response to environmental shifts. Incorporating agile principles enables firms to adjust their internal resource structures and external market behavior. Within the dynamic capability framework, organizations deliberately transform and realign resource bases to cope with turbulence in their operating environment. This theory emphasizes the ability of firms to merge and reshape existing competences into novel ones that sustain competitiveness in volatile markets (Arokodare & Asikhia, 2020). Teece (2007) conceptualizes this framework around three central functions: the ability to detect and shape opportunities, the capacity to seize them, and the ongoing reconfiguration of enterprise assets to maintain advantage. Building on this foundation, scholars have differentiated between two main dimensions of agility: strategic and operational (Lorenz, Bäckert, Heck, & Johannes, 2020).

Operational agility relates to adaptive adjustments within an organization, particularly in manufacturing and innovation processes. Transitioning to an agile orientation requires transforming internal operations to support incremental and continuous adaptation in both core and adjacent business domains (Lorenz, Bäckert, Heck, & Johannes, 2020). The aim is to sustain customer value under shifting market conditions by innovating close to existing offerings, without necessarily pursuing disruptive market creation (Denning, 2018). Sadjak (2015) identifies three enablers of operational agility: anticipating market needs, reducing the technical cycle of product development, and shortening production cycles while maintaining flexibility in the product portfolio. Two key distinguishing elements are emphasized: the qualitative responsiveness of products to evolving customer expectations and the speed with which firms execute design and production adjustments.

In the petroleum downstream sector, technology is understood as the application of innovation and knowledge in logistics to enhance operational efficiency. Contemporary trends in oil and gas highlight automation, digitalization, and intelligent systems as critical drivers of transformation. ICT applications in particular have been identified as pivotal enablers of efficiency across the value chain. Logistics, as a core component of the oil and gas supply system, enhances competitiveness by ensuring timely, efficient, and precise delivery of products (Aslam et al., 2022). ICT has been recognized as the cornerstone of the transition from conventional to smart supply chains, encompassing stages such as enterprise resource planning, customer-focused product innovation, organizational stabilization, and ultimately a redesigned supply chain that enables both product and process innovation. In line with this, the present study employed a Likert-scale instrument to assess respondents' perceptions of ICT-related impacts and their influence on petroleum product distribution efficiency.

Lisitsa, Levina, and Lepekhin (2019) argue that the integration of ICT with coordinated management processes yields more resilient logistics systems capable of improving customer service through better product availability and shorter order cycles. Such integration facilitates both information sharing (e.g., forecasting, inventory control, and delivery scheduling) and structural collaboration (such as just-in-time systems, outsourcing, vendor-managed inventory, and co-location strategies). These collaborative arrangements with downstream partners ultimately create customer value while minimizing supply chain inefficiencies. However, in Nigeria, the absence of requisite advanced technologies has constrained efficiency in petroleum logistics. Itsekor (2018) contends that Nigeria must depend on technology imports to address refinery limitations and distribution bottlenecks, given systemic technological underdevelopment. Persistent challenges include the failure to domesticate science and technology, deterioration of petroleum infrastructure, weak maintenance of standards, and the poor state of refineries, pipelines, and terminal facilities.

Eteyen (2024) examined digital transformation strategies, including AI and big data, for enhancing supply chain efficiency in Nigeria's oil sector. The study finds that advanced analytics improve decision-making, predictive maintenance, inventory management, and risk mitigation, thereby enhancing logistics agility. However, challenges such as poor infrastructure, skills shortages, and resistance to change limit impact. Strategic investment in technology and workforce development is essential for success. Terab, Umar & Oyedeji (2023) explore information technology usage in supply chain management within Nigeria's petroleum sector. Based on interviews with key stakeholders, it outlines how IT tools (e.g., ERP, tracking systems) are being integrated to enhance transparency, coordination, and responsiveness, key components of logistics agility. While adoption is growing, implementation remains uneven across companies. Ucheobi et al (2025) present a comprehensive review and survey on agile logistics challenges in petroleum distribution in Nigeria. They identify bottlenecks as scarcity, price volatility, infrastructural constraints, and propose that leveraging ICT (especially IoT-enabled tracking, real-time communication platforms, and digital coordination tools) can significantly improve agility by enabling faster response and smoother distribution flows. Collectively, these studies underscore that ICT integration, especially AI, big data analytics, ERP systems, and IoT tracking, enhances sensing, seizing, and transforming capabilities relevant to logistics agility. Real-time visibility, predictive maintenance, and responsive routing are recurring themes. However, implementation remains constrained by infrastructural limitations, skilled labour shortages, and uneven adoption across stakeholders. Gaps remain in quantitative, context-specific evaluations of ICT's direct impact on distribution metrics (e.g., lead times, stockouts, and responsiveness) in the petroleum sub-sector.

3. Methodology

The study employed both interviews and structured questionnaires as primary data collection instruments, directed at the Major Oil Marketers Association of Nigeria (MOMAN). MOMAN, founded in 2001 and formally incorporated in 2006, occupies a central role in shaping industry practices and ensuring adherence to regulatory benchmarks in the downstream petroleum sector. The association addresses collective challenges in product distribution and marketing while serving as an advocacy body that engages policymakers, provides technical guidance, and communicates industry perspectives to the government, media, and wider society. Additionally, it functions as a knowledge hub for stakeholders seeking industry-related information.

Approximately 65% of Nigeria’s petroleum products are supplied through MOMAN’s extensive network of retail outlets nationwide. The association’s initiatives span across driving industry reforms, establishing Health, Environment, Safety, and Quality (HESQ) benchmarks, fostering collaborations to reduce supply chain costs, and advancing data-driven decision-making for improved efficiency. As reported by Nnodim and Akintoye (2022), MOMAN initially comprised seven core members until 2022, when the Nigerian National Petroleum Company (NNPC) expanded membership to 27 firms. Each member typically operates multiple tank farms and maintains a minimum of 50 retail stations across the country to strengthen product availability and distribution reliability.

For this study, data collection concentrated on the seven pioneering marketers- Total Energies, OVH Energy (Oando), MRS, Conoil Plc, Ardova Plc, 11 Plc, and NNPC Retail Limited, given their longstanding influence and dominance in Nigeria's downstream supply landscape. The qualitative data is sourced primarily through the administration of structured questionnaires with regards to the requisite objectives addressed. Data was collected from their office and operational base in Lagos and Abuja, respectively The study questionnaire was administered to 210 executive staff of the research companies drawn from sales, marketing, admin, HR, imports, finance, business analyst, logistics and transport units of selected 7 major oil marketers through one-on-one interviews after which they were allowed time to fill out the questionnaires and drop it off with the HR from which the research returned to pick them. Analysis of the questionnaire presented in Table 1 shows a good return rate from the respective companies. The target sample size is selected following the Taro Yamani model.

Table 1. Data Instrument Analysis

Company	Questionnaires Distributed	Returned and Valid	% Returned and Valid
Total Energies	30	28	13
OVH Energy (Oando)	30	27	13
MRS	30	26	12
Conoil Plc	30	27	13
Ardova Plc	30	27	13
11 Plc (Mobil)	30	28	13
NNPC Retail	30	24	11
Total Energies	210	187	89

Source: Authors Field Survey

The Cronbach's alpha was conducted to assess the reliability of each scale. From Tables 2 and 3, Alpha values over 0.7 indicate that all scales can be considered reliable.

Table 2. Reliability Statistics for Best Distribution Options

Cronbach's Alpha	N of Items
.801	187

Table 3. Reliability Statistics for ICT Effects on Distribution Efficiency

Cronbach's Alpha	N of Items
.834	187

The effect of ICT integration on agile logistics and its variables on petroleum products distribution performance follows through the refineries, whether locally or imported, transportation, and chain information flows on the dependent variables of product distribution performance, exemplified in Table 4. Data analysis follows the regression model and Analysis of Covariance (ANOVA). Data source is primarily through the administration of questionnaires.

Table 4. Variables of Technology Integration for Agile Distributions

Dependent Variable	Independent Variable	Type	Analytical Tool
Effective Communication **Effective planning** **Effective demand forecast and responsiveness** **Cost optimization** **Product availability report** **Cost-effective pricing**	ICT Integration (Production Supply, transportation, and information integration)	Primary	Regression and ANOVA

Source: Authors

4. Results and Findings

4.1 Temporal analysis of distribution software in other sectors and possible application in petroleum distribution

The deployment of information technology in supply chains has created what is often described as a "virtual supply chain," where data, rather than physical inventory, forms the foundation of coordination. Unlike traditional logistics systems that focus on determining optimal inventory levels and geographic placement, supported by complex mathematical models and algorithms, the virtual approach relies on real-time information visibility. With demand transparency achieved through shared data, many assumptions underlying inventory-based optimization models become less relevant. Technologies such as Electronic Data Interchange (EDI) and Internet-based platforms now allow supply chain partners to access and act upon the same demand signals, thereby reducing the distortions and delays typically generated as orders cascade through successive stages of the chain.

Within the oil and gas sector, digital solutions have become indispensable for improving efficiency across exploration, production, processing, and distribution activities. These software platforms provide advanced functionalities for data interpretation, modeling, simulation, and process optimization, ultimately enhancing profitability and operational performance. Five widely recognized software systems in oil and gas exploration and production include:

(a) Petrel (Schlumberger): An integrated platform for geological interpretation and modeling. It facilitates the creation of three-dimensional reservoir models and supports fluid flow simulation to optimize hydrocarbon recovery.
(b) Landmark (Halliburton): A comprehensive suite for exploration and production that integrates data from multiple sources to support reservoir modeling, drilling design, and production optimization.
(c) Eclipse (Schlumberger): A reservoir simulation tool designed for modeling complex reservoirs and predicting fluid behavior, enabling proactive resolution of potential production challenges.
(d) Aspen HYSYS (AspenTech): A process simulation software extensively used for modeling operations such as separation, purification, and transportation, aimed at optimizing process design and minimizing operating costs.
(e) OFM (Schlumberger): A production analysis application that tracks well performance, monitors production data, and identifies inefficiencies to support improved output and profitability.

While software applications for exploration, production, and processing are widely recognized in the industry, there is no specifically identifiable software dedicated to the marketing and distribution of petroleum products. However, the research identifies in Table 5 how the following software applications implemented by the listed industries could find practical applications in the petroleum product marketing towards agile operation and distribution.

Table 5. Distribution Software Application and Industry Application

Distribution Software	Industry	User Firm	Possible Application in Petroleum Distribution
Dynamics 365 Business Central	Supply Chain Logistics and Distribution Consumer Packaged Goods Oil and Gas ecommerce Manufacturing	Coca-Cola TD Africa 21st Amendment Brewery HP Nestlé Duke Energy Philips corporation	Financial forecasting and reporting Business integration Project planning Asset tracking Inventory management Seamless resource planning Customer engagement Improved decision-making process
EDI Solutions	Supply Chain Logistics and Distribution Retail and wholesale business	HP TD Africa Redington Walmart Coca-Cola	Supply Chain integration Inventory management Digital storefronts Marketplaces
ShipStation	ecommerce Supply chain Logistics	eBay Amazon FedEx UPS	Insights Ordering Shipments and delivery management Products management Customer relations
NetSuite	Manufacturing Supply Chain Technology Support Logistics	Secrid Brandwatch UPS Charlotte Tilbury Shaw Industries	Traceability Stock replenishment Cycle counting Retail and trade sales information Regional integration Reliable analysis and insights Inventory management
Quickbooks	ecommerce Oil and Gas Retail Pharmaceuticals Construction and Real Estate Professional Services	ENI VIZIO Inc3 Pharmaceuticals 150 Hooper	Sales insight Inventory management Operation Integration Asset income, labour, material, and Cost tracking Inventory management

Source: Authors

4.2 Best Strategies in Petroleum Product Distribution

In light of the level of agility estimate and sampled challenges to agile distribution. The study sought to examine best strategies relating to tactics, techniques, and tools options that the distribution and marketing company, as well as government stakeholders, could integrally adopt to streamline petroleum product distribution and deliver customer values most efficiently, alleviating the challenges sampled and boosting levels of agility. The perceived strategies of best distribution option spring from a review of related literature in this regard. These are presented to the respondents on a 5-point Likert scale to sample their level of disagreement with them.

Table 6. Descriptive Statistics of Best Distribution Options

Options	N	Min.	Max.	Mean	Std. Deviation
BDO_1: Large-scale storage for efficient distribution	187	2.00	5.00	4.2995	.85267
BDO_2: Improved and efficient pipeline network	187	3.00	5.00	4.3743	.75419
BDO_3: Supplier segmentation for resource optimization	187	3.00	5.00	4.4973	.65068
BDO_4: Integrated ICT system for efficient management	187	3.00	6.00	4.5134	.71360
BDO_5: Investment in local refinery to boost supply	187	3.00	5.00	4.3422	.74088
BDO_6: Investment in local expertise for efficient operation	187	2.00	5.00	4.3529	.73582
BDO_7: Integrated management system and process	187	2.00	5.00	4.3155	.81776
Valid N (listwise)	187				

Source: Authors

Table 6 presents the descriptive statistics of sample best practice strategies to improve the agility of petroleum product distribution, having surveyed the level of agility and challenges to distribution agility. The sample constitutes 187 respondents. The minimum and maximum value responses for the sample variables regarding the five-point Likert scale are between 2 and 5 for the variables $BDO_{1,}$ $BDO_{6,}$ and $BDO_{7,}$ representing the options of large-scale storage, investment in local expertise, and ICT system, respectively. The variables BDO_2 – $BDO_{5,}$ representing samples of pipeline efficiency, ICT systems, boost in local supply, and supplier segmentations, have minimum values of 3 and 5, respectively. The mean ratio of all sample variables ranged between 4.2 and 4.5, with the sample data of ICT system having the highest mean value of 4.5. The higher mean scores greater than the Likert mean value 3 and mean deviation less than the Likert mean for all data parameters, respectively, show that the respondents agree that the perceived strategic options are the best options to revolutionize petroleum product distribution in Nigeria to deliver the best customer values. The analysis is followed by a K-S Test to further verify the validity of the result.

Table 7. One-Sample Kolmogorov-Smirnov Test for Best Agile Strategic Options

		BDO_1	BDO_2	BDO_3	BDO_4	BDO_5	BDO_6	BDO_7
N		187	187	187	187	187	187	187
Normal Parameters[a,b]	**Mean**	4.2995	4.3743	4.4973	4.5134	4.3422	4.3529	4.3155
	Std. Deviation	.85267	.75419	.65068	.71360	.74088	.73582	.81776
Most Extreme Differences	**Absolute**	.329	.337	.363	.383	.315	.308	.323
	Positive	.206	.203	.220	.242	.187	.190	.201
	Negative	-.329	-.337	-.363	-.383	-.315	-.308	-.323
Test Statistic		.329	.337	.363	.383	.315	.308	.323
Asymp. Sig. (2-tailed)		.000[c]	.000[c]	.000[c]	.000[c]	.000[c]	.000[c]	.000[c]

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.

Table 7 presents the K-S Test statistics for the best agile distribution option strategies. The data result is at par with the descriptive result of Table 6 regarding the mean value and standard deviation of the variables. The Kolmogorov-Smirnov results confirm that the response data for all Best Agile Strategic Options are not normally distributed, yet the consistently high mean scores indicate strong stakeholder preference across all seven strategies. Non-parametric statistical techniques should therefore be employed for subsequent hypothesis testing and comparative analysis. The One-Sample K-S test is used to check whether the distribution of data significantly differs from a normal distribution. It attempts to test the null hypothesis that the data for each Best Agile Strategic Option (BDO_1–BDO_7) follows a normal distribution. The means range from 4.29 to 4.51, showing consistently high agreement across all options, and the standard deviations range from 0.65 to 0.85, indicating relatively low dispersion around the mean. The test statistics (absolute K-S values) range from 0.308 to 0.383 across the options. The p-value all reported as 0.000 ($p < 0.05$) after Lilliefors correction. Since p-values are all < 0.05, the null hypothesis (normal distribution) is rejected for all seven options (BDO_1–BDO_7). This means the data distributions for the identified agile strategies significantly deviate from normality.

Practically, for the non-normal distribution, the responses for all strategic options (large-scale storage, pipeline network, supplier segmentation, ICT integration, local refinery investment, local expertise, and integrated management systems) are not normally distributed. Despite non-normality, the high means (>4.2 on a 5-point scale) with low standard deviations suggest that respondents strongly and consistently favour these strategic options to leverage agility in the distribution of petroleum products in Nigeria, but the skewness or kurtosis of the data likely caused deviation from normality. Among the strategies, BDO_4 (Integrated ICT system for efficient management) shows the highest mean (4.51) and the highest deviation from normality (K-S = 0.383, $p < 0.05$). This indicates very strong agreement, but with clustered responses (likely skewed towards the higher end of the scale).

4.3 Effect of ICT Integration on Agile Performance of Petroleum Distribution

Innovation in Information and Communication Technology is recognized by numerous researchers as an innovation strategy driving change in logistics and supply chain of oil and gas distribution. Abdulkareem, Anthony & Ike (2013) acknowledge that Information and Communication Technology (ICT) plays a critical role across the entire oil and gas value chain, encompassing upstream, midstream, and downstream activities. By enabling process optimization, ICT enhances both the efficiency and sustainability of sectoral operations. This study was designed to examine the influence of ICT on key variables associated with distribution agility. Data results in this regard, following the five-point Likert scale analysis with specific attention to Table 5, show an average mean response above 4, which is higher than the Likert mean value of 3, indicating the survey statements are true of the effect of ICT on the agile logistics sub-variables of petroleum distribution. ICT Integration supports logistics agility in oil and gas distribution value chain through improved information flow, commercial accountability, inventory, cost and resource management, mitigation of supply chain risk, facilitation of informed and better decisions, proper product positioning, operational monitoring and surveillance, and effectively matching demand with supply to deliver best end user values.

Table 8 presents the ICT variables defining the effect of ICT on the distribution of petroleum products. Data result shows that all the respondents ' sample mean values ranged between 4.4225 and 4.6684, with regard to the liker scale mean value, 3 agree to a large extent that the sampled variables are the effect of ICT on the performance of petroleum product distribution. The standard deviation values less than 3 also attest to this.

Table 8. Descriptive Statistics of ICT Effects on Distribution Efficiency

ICT Variables and their Description	N	Minimum	Maximum	Mean	Std. Dev.
ICT_{V1}: Availability of right information at the right time for various stakeholders	187	2.00	5.00	4.6684	.59317
ICT_{V2}: Improved efficiency and accountability through integrated ICT system to manage sales, purchase, stock, customer queries, and inventory (Q_2)	187	2.00	5.00	4.4278	.79574
ICT_{V3}: Cost management through transport resource, logistics, and inventory tracking (Q_3)	187	3.00	5.00	4.4920	.65884
ICT_{V4}: Positioning right products to right market (Q_4)	187	3.00	6.00	4.5615	.68800
ICT_{V5}: Effectively match demand with supply (Q_5)	187	3.00	5.00	4.4920	.66695
ICT_{V6}: Mitigate supply chain risk through facilitation of informed decisions in transport and distribution (Q_6)	187	3.00	5.00	4.5829	.61112
ICT_{V7}: Facility and retail outlet monitoring through GIS location-based Information (Q_7)	187	3.00	5.00	4.4225	.74641
Valid N (listwise)	187				

Source: Authors

Table 9. One-Sample Kolmogorov-Smirnov Test of ICT variables effect Agile Distribution

		ICT_{V1}	ICT_{V2}	ICT_{V3}	ICT_{V4}	ICT_{V5}	ICT_{V6}	ICT_{V7}
N		187	187	187	187	187	187	187
Normal Parameters^{a,b}	**Mean**	4.6684	4.4278	4.4920	4.5615	4.4920	4.5829	4.4225
	Std. Dev.	.59317	.79574	.65884	.68800	.66695	.61112	.74641
Most Extreme Differences	**Absolute**	.439	.363	.363	.401	.365	.400	.358
	Positive	.288	.236	.220	.257	.223	.247	.220
	Negative	-.439	-.363	-.363	-.401	-.365	-.400	-.358
Test Statistic		.439	.363	.363	.401	.365	.400	.358
Asymp. Sig. (2-tailed)		.000^c	.000^c	.000^c	.000^c	.000^c	.000^c	.000^c

a. Test distribution is Normal.
b. Calculated from data.
c. Lilliefors Significance Correction.
Source: Authors

The sample data of Table 8 was further subjected to a K-S test to investigate the validity and ensure the result is not by chance. K-test data result of Table 9 shows means responses higher than the Likert mean test value of 3, indicating the variables are true of ICT effects on product distribution efficiency. The data result of Table 8 is from a normal distribution and not by chance. In testing the null hypothesis that responses on each ICT variable follow a normal distribution, the means of responses range from 4.42 to 4.67, showing strong agreement across all ICT factors, with standard deviations ranging from 0.59 to 0.79, reflecting moderate variability. The K-S statistics range from 0.358 to 0.439, which are relatively high, indicating strong deviation from normality. All the p-values are

0.000 ($p < 0.05$) with Lilliefors correction. Since all p-values < 0.05, the null hypothesis is rejected for all ICT variables (ICT_{V1}–ICT_{V7}). This indicates that the response distributions significantly deviate from normality. ICT_{V1} (Timely information availability) with mean of 4.67 is the highest-rated variable. Strong consensus that timely access to information is crucial, but the skewed distribution suggests responses are clustered at the high end, reflecting overwhelming support. ICT_{V2} (Integrated ICT efficiency) with a mean value of 4.43 shows that respondents strongly agree that integrated ICT improves efficiency and accountability in managing sales, stock, and customer relations. ICT_{V3} (Cost management) with mean of 4.49 confirms ICT's role in logistics, transport, and inventory tracking is seen as highly effective for controlling costs. ICT_{V4} (Right product–right market) with mean of 4.56 strongly support that ICT ensures product placement aligns with market demand.

In addition, ICT_{V5} (Demand–supply matching) with mean of 4.49 affirms that ICT tools are critical in balancing demand and supply, which is particularly important in petroleum distribution given volatility. ICT_{V6} (Risk mitigation) with mean value of 4.58 is one of the strongest-rated variables. Thus, ICT enables informed decision-making to minimize risks in transport and distribution. Finally, ICT_{V7} (GIS-based monitoring) with mean of 4.42 supports high value for facility and outlet monitoring, though slightly lower than others, still indicating strong acceptance. The practical implications for Nigeria's petroleum distribution despite the non-normality and the high mean scores (>4.4) reveal that stakeholders overwhelmingly endorse ICT as a driver of agile distribution. Real-time information (ICT_{V1}) and risk management (ICT_{V6}) stand out as the most critical agility enablers. GIS monitoring (ICT_{V7}) is slightly less emphasized, but still important for distribution transparency and network oversight. The policy and industry implications show that effective deployment of ICT systems can enhance transparency in supply chain operations, improve demand forecasting and inventory management, reduce inefficiencies, losses, and supply chain risks and ensure more responsive and agile petroleum product distribution across Nigeria, mitigating shortages and improving customer satisfaction.

4.4 Test of Hypothesis

The study further tested the following null hypothesis:

H_{01} There is no significant relationship between investment in ICT and agile petroleum distribution performance.

Table 10. Model Summary of the ICT Adoption for Agile Distribution

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.591[a]	.349	.345	2.88654

a. Predictors: (Constant), ICT variables

Table 11. Regression Model for the ICT Adoption for Agile Distribution

Model		Unstandardized Coefficients B	Unstandardized Coefficients Std. Error	Standardized Coefficients Beta	t	Sig.
1	(Constant)	-4.934	2.452		-2.012	.046
	ICT variables	.766	.077	.591	9.930	.000

a. Dependent Variable: Agility Performance

From Tables 10 and 11, it can be said that a correlative relationship exists between the two variables tested, given the R value of 59.1%. What this depicts is that agile petroleum distribution performance correlates at 59.1% with a sample of ICT variables. Also, R^2 shows the percentage of the total variation of the dependent variable that is explained by the independent variable. This shows that there is a significant relationship between agile distribution performance and ICT capabilities. According to our analysis, $R^2 = 0.349$ (35%), which implies that the variation in agile petroleum distribution performance is explained by changes in ICT innovation implementation. The remaining 65% variation is explained by factors that are not captured in the model.

Table 12. ANOVA for the ICT Adoption for Agile Distribution

Model		Sum of Squares	df	Mean Square	F	Sig.
1	**Regression**	821.539	1	821.539	98.599	.000[b]
	Residual	1533.107	184	8.332		
	Total	2354.645	185			

a. Dependent Variable: Agility Performance
b. Predictors: (Constant), ICT variables

The F value of 98.599 and P value of 0.000 at a 0.05 significance level, the ANOVA indicates that the variables have a significant effect on the response variable (see Table 12). This is also confirmed by t - calculated of 9.93, which is greater than t-tabulated of 1.976. Following these, we reject the H_{01} and accept that ICT variables have a significant effect on agile distribution performance of petroleum products. The regression model is estimated with specific attention to Tables 10 and 11. The regression coefficient 0.766 (76.6%) indicates that a % improvement in ICT investment will bring about an average of 76.6% in agile petroleum distribution performance at a regression constant (β_0) of -4.934 and standard error (€) of 0.077.

5. Implication

Innovation in ICT is acknowledged as the innovation driving change not only in the downstream sector but also in the mid and upstream sectors. The sub-variables of agile logistics in the distribution of petroleum products relate to speed, safety, and availability of products to the end user at affordable cost. The study finding shows that ICT capabilities support the operational efficiency and performance of the value chain. Innovation in ICT systems and applications enables the integration of all organizational functions into a single workflow with end-to-end visibility of value chain operation beginning from product sourcing, transportation, and retail sales. The capability of the ICT GIS system supports monitoring supply chain infrastructure, trace and track logistics vehicles, stock, sales, transportation, and organizational resources, improving accountability, mitigating losses, theft, and mismanagement of resources. ICT system eliminates the inefficiencies of manual process and boosts operational speed, eliminates error, and supports timely and quick information flows amongst the various chain stakeholders. Information technology plays a pivotal role in ensuring seamless information flow across the highly complex supply management processes of the oil sector. Achieving efficiency in petroleum product supply requires a holistic view of the logistics chain, spanning from refining to commercial distribution. As highlighted by Dike, Anthony, and Abdulkareem (2013), oil companies recognize ICT as a critical enabler for enhancing operational efficiency, supporting informed managerial decision-making, and sustaining competitiveness in volatile market conditions. Through ICT, firms are able to store, process, and manage multilayered data related to crude oil procurement, refining activities, and the distribution of finished petroleum products. Agility in this context is driven by logistics processes that are lean, responsive, adaptable, and cost-efficient. Attaining such a system requires a multidimensional approach involving institutional reforms, infrastructure upgrades, and the integration of digital technologies (Ucheobi et al, 2025).

Innovation in ICT is new technologies driving change in oil and gas distribution. There exists a technology gap in petroleum product distribution in Nigeria. This is also a significant reason for the low levels of distribution agility. ICT system and application adoption is necessary for end-to-end integration of the distribution function and management process of the value chain, beginning from the point of product sourcing, lifting, transportation tracking, delivery, sales, and inventory reporting, planning, and supply schedule into a single workflow, enabling real-time visibility of the distribution functions. This leads to benefits in the elimination of the inefficiencies of the silos manual system, mitigation of thefts, improved delivery times, accountability, security, and safety of products, effective supply schedule to adequately match market demands, quick and informed decisions to timely deliver the right products, to the right places at efficient cost. Relative to technology growth in the sector, there exists an observed technology gap in the operations of the oil marketing and distribution organization in Nigeria. Innovation in ICT is required for operational efficiency and improved performance of the value chain. Up till now, the capabilities of ICT systems and applications have not been well adopted by the marketing and distribution companies. The operation is fraught with inefficiencies of the manual system, lacking capability in process and operational integration of organizational business functions. The Oil marketing system will reap benefits in operational efficiency, improved performance, and profitability if it concentrates efforts on investment in ICT integration of its business function. The study hypotheses indicate that there exists a positive, significant relationship between distribution agility and human resource challenges, ICT capabilities, and new strategies in agile distribution identified in the research. This goes to say that investment in the expertise, skill, knowledge, and motivation of the workforce, adoption of ICT innovation in the value chain process, and agile strategies, including a boost in local supply capacities and improved road and pipeline networks, will support adequate supply of quality products at competitive pump price.

Now that industry is fully deregulated, competition is driven by individual company capability and efficiency. Innovation in the industry has thus become necessary. The petroleum marketing and distribution companies should invest in building HR capacities to develop the skill set and knowledge necessary to deliver quality customer values and be competitive. The need to invest in innovation in ICT for operational efficiency and improved performance cannot be overemphasized. Innovations in ICT are a strategy to stay ahead of competition through cost efficiency, market responsiveness, operational flexibility, and services that meet and exceed customer expectations. Innovations in ICT support quality of service by improving customer satisfaction, optimizing the inventory costs and total costs, effectively matching demand with supply, and more. Cost efficiency arises from improved supply chain visibility, compliance, and supplier collaboration.

6. Conclusion

For oil companies, the deployment of ICT is essential to enhance both efficiency and effectiveness in operations while also supporting evidence-based managerial decision-making. An integrated ICT framework enables firms to minimize the resources required to achieve desired customer satisfaction levels by improving product availability and reducing order cycle times. This is accomplished through mechanisms such as information exchange (demand forecasting, inventory tracking, and delivery scheduling), structural collaboration (just-in-time systems, outsourcing, vendor-managed inventory, and plant co-location), and strengthened partnerships with downstream actors, all of which generate end-user value, lower costs, and improve competitiveness across the distribution chain. ICT also underpins the smooth management of information flows within petroleum marketing and distribution. Material and financial flows are closely tied to information movement, and disruptions in data sharing such as inadequate forecasting, insufficient market intelligence, or capacity gap can create distortions, including the bullwhip effect. Given the high level of uncertainty and competitive pressure in Nigeria’s petroleum sector, oil companies are compelled to increase productivity while conserving resources. ICT capability thus becomes a strategic requirement for sustaining competitiveness in dynamic environments. As Umuteme (2021) emphasizes, ICT integration is central to driving operational excellence, enabling process digitalization across logistics and supply chains, and transforming distribution systems into more efficient, optimized, and value-generating operations.

Appendix

Structured Questionnaire

The questionnaire is about research on ICT integration in improving agile logistics agility of the distribution of petroleum products in Nigeria. Your support is solicited by the questionnaire to provide information required to make the research worthwhile. Please, respond to the questions as appropriate and mark relevant box with √.

Question 1. Possible Agile Distribution Strategies

Agile Strategic Options	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Large scale storage for efficient distribution					
Improved and efficient pipeline network					
Supplier segmentation for resource optimization					
Integrated ICT system for efficient management					
Investment in local refinery to boost supply					
Investment in local expertise for efficient operation					
Integrated management system and process					

Question 2. The Effect ICT Implementation on Agile Distribution

ICT Role in Agile Distribution	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Availability of right information at right time for various stakeholders					
Improved efficiency and accountability through integrated ICT system to manage sales, purchase, stock, customer queries and inventory					
Cost management through transport resource, logistics and inventory tracking					
Positioning right products to right market					
Effectively march demand with supply					
Mitigate supply chain risk through facilitation of informed decisions in transport and distribution					
Facility and retail outlet monitoring through GIS location-based Information					

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