

ASSESSMENT OF INFORMATION TECHNOLOGY INFRASTRUCTURAL DEVELOPMENT AND SHIPPING OPERATIONS PERFORMANCE IN NIGERIAN MARITIME INDUSTRY

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Abstract

This study evaluated the impact of information technology infrastructure development on shipping operations performance in Nigeria maritime industry. Specifically, it examined how Network Infrastructure (NI), Hardware Infrastructure (HI), Software Infrastructure (SI), and Peopleware Infrastructure (PI) influence Tracking and Tracing of Consignments (TTC), Timeliness in Cargo Delivery (TCD), Route Optimisation (RO), and Supply Chain Integration (SCI). The study was guided by four objectives, research questions, and null hypotheses. A descriptive survey design was adopted, and primary data were collected through a structured questionnaire measured on a four-point Likert scale. The study population comprised 200 maritime-sector personnel, including warehouse operators, shipping managers, freight forwarders, inventory managers, and other port and shipping personnel. Using Taro Yamane's formula, a sample size of 133 respondents was selected for the study. Data were analysed using descriptive statistics and multiple regression analysis. The findings revealed that information technology infrastructure significantly improved shipping operations performance. A unit increase in NI, HI, SI, and PI resulted in improvements of 2.022, 1.256, 3.075, and 1.242 units respectively in Tracking and Tracing of Consignments. Similarly, a unit increase in NI, HI, SI, and PI produced improvements of 6.044, 3.138, 1.155, and 2.010 units respectively in Timeliness in Cargo Delivery. The results further showed improvements of 1.082, 2.128, 1.031, and 2.030 units respectively in Route Optimisation, while Supply Chain Integration improved by 1.110, 2.042, 3.091, and 2.104 units respectively. Therefore, the null hypotheses were rejected, indicating that network, hardware, software, and peopleware infrastructure significantly influence shipping operations performance in Nigeria maritime industry. The study concludes that IT infrastructure development is vital to efficient maritime logistics, as reliable networks enable real-time information exchange, modern hardware supports cargo monitoring, software improves operational coordination, and skilled personnel ensure effective technology utilisation. The study recommends that the Nigerian Ports Authority, terminal operators, shipping companies, and other maritime stakeholders should invest in reliable and integrated network infrastructure, interoperable software systems, modern tracking equipment, and continuous digital-skills training to improve cargo visibility, delivery timeliness, route efficiency, and supply-chain integration.

Keywords: Information Technology Infrastructure; Shipping Operations Performance; Maritime Logistics; Supply Chain Integration

Introduction

The contemporary business environment is increasingly shaped by globalization, intensified competition, technological disruption, changing customer expectations, and the growing availability of digital data (Esmail, 2016). These forces

require organisations to develop capabilities that enable them to process information quickly, coordinate activities across organisational boundaries, and make timely operational decisions. In logistics-intensive sectors, the ability to transform data into useful information is particularly important

because service delivery depends on the efficient coordination of cargo flows, transport assets, inventory, documentation, personnel, and customer requirements (Nwaogbe et al., 2016). Information technology (IT) infrastructure has consequently become a strategic resource for improving organisational responsiveness, operational visibility, and competitive performance (Nwaogbe et al., 2016). IT infrastructure refers to the foundational technological resources that support the collection, storage, processing, exchange, and protection of organisational information (Nwaogbe et al., 2019). It includes network infrastructure, computer hardware, software applications, databases, communication systems, cybersecurity arrangements, and the human expertise required to operate and manage these technologies (Obioma et al., 2021).

In the maritime and logistics environment, effective IT infrastructure enables stakeholders to access accurate information, automate routine processes, coordinate cargo movements, monitor vessel and truck activities, and make evidence-based decisions (Peter et al., 2026). Digitalisation through artificial intelligence, automation, blockchain, port community systems, and electronic data exchange is increasingly recognised as important for improving port operations, cargo handling, tracking, and maritime supply-chain efficiency (Pedro et al., 2026; Caldeirinha et al., 2020). UN Trade and Development notes that digital technologies can reduce waiting times, improve cargo tracking, strengthen transshipment efficiency, and support more effective port operations (UN, 2024). Shipping operations constitute a central component of maritime logistics and supply-chain management. They involve the planning, coordination, execution, and control of activities required to move cargo from origin to destination through maritime transport networks (Peter et al., 2026). These activities include vessel scheduling, cargo booking, documentation, customs clearance, cargo handling, warehousing,

inventory control, routing, distribution, freight forwarding, and delivery coordination. Shipping operations also require the continuous interaction of multiple actors, including port authorities, terminal operators, shipping lines, freight forwarders, customs agencies, transporters, warehouse operators, consignees, and other logistics service providers. The effectiveness of shipping operations therefore depends not only on physical infrastructure but also on the availability of integrated digital systems that enable information to move accurately and quickly among stakeholders (Omoke et al., 2017). The importance of shipping operations is evident in the role of maritime transport in international trade. More than 80% of global merchandise trade by volume is transported by sea, making ports and shipping systems critical gateways for national and international supply chains (Omoke et al., 2017). Efficient shipping operations can reduce cargo dwell time, minimise documentation delays, improve vessel turnaround time, enhance the predictability of cargo delivery, and lower logistics costs (Nwaogbe et al., 2024).

Conversely, weak coordination, manual processes, poor information flow, unreliable communication networks, and inadequate digital systems can create congestion, delay cargo clearance, reduce traceability, increase operating costs, and undermine customer satisfaction (UNCTAD, 2024). For shipping companies and port-related organisations, operational performance is commonly assessed using key performance indicators (KPIs) (Ha, & Yang, 2017). KPIs help managers monitor whether shipping and logistics processes meet expected standards of cost, time, accuracy, quality, reliability, and customer service (Ha, & Yang, 2017).

In the context of this study, shipping operations performance is examined through four key dimensions: tracking and tracing of consignments, timeliness in cargo delivery, route optimisation, and supply-chain integration. Tracking and tracing refer

to the ability to monitor the location, status, movement, and condition of cargo throughout its journey (Ha, & Yang, 2017). Timeliness in cargo delivery concerns the extent to which goods are delivered according to scheduled or agreed delivery times (Pedro et al., 2026). Route optimisation involves selecting efficient movement paths that reduce distance, congestion, fuel use, delays, and transport costs (Álvarez et al., 2024). Supply-chain integration reflects the degree of coordination, information sharing, and process alignment among supply-chain actors (Chuku et al., 2025). Network infrastructure is essential for these performance dimensions because it supports real-time communication and data transfer between shipping firms, port operators, customers, customs agencies, warehouses, and transport providers (Chuku et al., 2025). Reliable networks permit electronic documentation, online cargo-status updates, integrated booking systems, and rapid exchange of operational information. Hardware infrastructure including computers, servers, scanners, tracking devices, mobile terminals, sensors, and communication equipment that provides the physical capacity for capturing and processing logistics data (Chuku et al., 2025; Pedro et al., 2026). Software infrastructure, such as transport-management systems, warehouse-management systems, enterprise resource planning platforms, cargo-tracking applications, and port-management systems, assists organisations in planning, monitoring, coordinating, and evaluating operations (Viktor et al., 2023).

Equally, peopleware infrastructure refers to the human resources, technical competencies, digital skills, training, and organisational support necessary for the effective utilisation of network, hardware, and software resources (Viktor et al., 2023). The global movement towards smart ports and digital maritime ecosystems has reinforced the relevance of IT infrastructure to shipping performance. Digital platforms such as maritime single windows and port

community systems allow stakeholders to exchange documentation and operational information through integrated electronic channels (Viktor et al., 2023). These systems can reduce administrative burdens, support paperless processes, enhance transparency, and improve coordination across port and logistics networks. UNCTAD identifies digitalisation, automation, customs integration, cross-border data exchange, and single-window platforms as important mechanisms for improving port efficiency, interoperability, trade facilitation, and supply-chain resilience (UNCTAD, 2026).

Nigeria maritime industry plays an important role in national trade, industrial supply, customs revenue, and economic development. The ports of Apapa and Tin Can Island in Lagos are especially significant because they handle a substantial share of Nigeria containerised cargo and serve as major gateways to domestic and regional markets (Nwaogbe et al., 2024). The operational performance of these ports and their associated shipping and logistics actors has implications for manufacturers, importers, exporters, consumers, freight forwarders, and government agencies (Wang et al., 2025). Recent analysis of Apapa Port and Tin Can Island Port has consequently focused on comparative operational-performance indicators, demonstrating the strategic importance of improving performance within these port systems (Omoke, et al., 2017; Nwaogbe, et al., 2024). Nigeria has also begun to pursue digital initiatives intended to improve port efficiency and trade facilitation. The Nigerian Ports Authority has reported efforts toward a Port Community System, National Single Window integration, electronic truck call-up management, e-tag verification, joint boarding applications, and electronic systems intended to reduce cargo dwell time and vessel turnaround time (Afolayan, 2024). It reported that average vessel turnaround time improved from 4.7 days in 2023 to 4.6 days in 2024, alongside

an increase in berth occupancy from 30.1% to 33.0% (Attaran, 2020).

These developments demonstrate the practical relevance of digital infrastructure in improving information exchange, traffic management, cargo processing, and port-operational outcomes. Nevertheless, the effectiveness of these initiatives depends on the adequacy and integration of network facilities, hardware resources, software systems, and staff capacity across the maritime logistics ecosystem (Caldeirinha, et al., 2020; Edih, et al., 2022).

Statement of the Problem

Despite the increasing importance of digital technologies in global shipping and port operations, IT infrastructure development remains an important operational concern in Nigeria maritime industry. Many shipping and port-related processes continue to face challenges associated with fragmented information systems, limited integration between stakeholders, manual documentation, inadequate real-time cargo visibility, inconsistent network connectivity, insufficient technology investment, and gaps in user competence (Gasparotti, et al., 2023). These challenges can negatively affect the tracking and tracing of consignments, timeliness of cargo delivery, route planning, and supply-chain integration (Gasparotti, et al., 2023). The challenge is not merely the availability of technology but the ability of maritime organisations to deploy and integrate it strategically. Investments in network facilities, hardware, software, and digital skills may fail to produce expected operational benefits where systems are not interoperable, users are inadequately trained, organisational processes remain manual, or stakeholders do not share data effectively (Dongping, 2021).

Digital infrastructure projects also require significant capital investment, management commitment, cybersecurity safeguards, maintenance arrangements, and continuous technical upgrading (Attaran,

2020). Consequently, decision makers may find it difficult to justify infrastructure investments where the direct relationship between IT infrastructure development and shipping operations performance has not been empirically established (Attaran, 2020). Existing evidence has established that digitalisation can improve port efficiency, cargo handling, tracking, information exchange, and trade facilitation (Attaran, 2020). However, there remains a need for context-specific empirical evidence on how different dimensions of IT infrastructure influence shipping operations performance within Nigeria maritime industry, particularly among logistics and port-service organisations connected with Apapa and Tin Can Island ports (Afolayan, 2024).

This study therefore addresses this gap by examining the impact of network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure on tracking and tracing of consignments, timeliness in cargo delivery, route optimisation, and supply-chain integration (Viktor, 2023).

Aim and Objectives

The aim of this study is to examine the impact of information technology infrastructure development on shipping operations performance in Nigeria maritime industry.

The specific objectives are to:

1. Determine the impact of network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure on the tracking and tracing of consignments in Nigeria maritime industry.
2. Examine the impact of network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure on timeliness in cargo delivery in Nigeria maritime industry.
3. Assess the impact of network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure on route optimisation in Nigeria maritime industry.

4. Determine the impact of network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure on supply-chain integration in Nigeria maritime industry.

Research Questions

The following questions guide the study:

1. To what extent do network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure affect the tracking and tracing of consignments in Nigeria maritime industry?
2. To what extent do network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure affect timeliness in cargo delivery in Nigeria maritime industry?
3. To what extent do network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure affect route optimisation in Nigeria maritime industry?
4. To what extent do network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure affect supply-chain integration in Nigeria maritime industry?

Research Hypotheses

The following null hypotheses were tested at the 0.05 level of significance:

H01: Network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure do not significantly predict the tracking and tracing of consignments in Nigeria maritime industry.

H02: Network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure do not significantly predict timeliness in cargo delivery in Nigeria maritime industry.

H03: Network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure do not significantly predict route optimisation in Nigeria maritime industry.

H04: Network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure do not significantly predict supply-chain integration in Nigeria maritime industry.

Significance and Scope

This study contributes to scholarship by providing empirical evidence on the relationship between IT infrastructure development and shipping operations performance in Nigeria maritime industry. It is expected to assist port authorities, shipping companies, terminal operators, freight forwarders, customs agencies, warehouse operators, logistics providers, and policymakers in identifying technology investments that can improve cargo visibility, delivery timeliness, route efficiency, and supply-chain coordination. The findings may also guide managers in prioritising investments in network connectivity, hardware facilities, software applications, and employee digital skills. For policymakers, the study can support decisions relating to port digitalisation, port community systems, maritime single windows, electronic documentation, and broader trade-facilitation reforms. It will further serve as a useful reference for future researchers interested in information technology, maritime logistics, port performance, supply-chain integration, and shipping operations in Nigeria.

Geographically, the study focuses on maritime logistics organisations and port-related stakeholders operating within Apapa and Tin Can Island ports in Lagos State, Nigeria. Content-wise, it is limited to four dimensions of IT infrastructure; network, hardware, software, and peopleware infrastructure and four dimensions of shipping operations performance; tracking and tracing of consignments, timeliness in cargo delivery, route optimisation, and supply-chain integration. The study is grounded in the Resource-Based View and Dynamic Capabilities Theory, which emphasise the importance of valuable organisational resources and the capability

to integrate, reconfigure, and deploy such resources in response to changing operational conditions

Literature Review

This study was anchored in the Resource-Based View (RBV) and Dynamic Capabilities Theory. Together, the theories explain how organisations use valuable resources and continuously adapt those resources to improve operational performance in changing business environments.

The Resource-Based View, advanced by Barney in 1991, explains that firms achieve sustained performance by possessing and effectively managing resources that are valuable, rare, difficult to imitate, and properly organised. These resources may be tangible, such as infrastructure and equipment, or intangible, such as knowledge, organisational systems, relationships, and technological expertise. The theory suggests that organisations with superior resources and capabilities can implement strategies that create customer value through improved efficiency, lower costs, reliable service, and responsive operations. In logistics and shipping, IT infrastructure constitutes a strategic resource because network systems, hardware, software, databases, and employee expertise support information exchange, cargo visibility, transport coordination, and supply-chain integration. The RBV is therefore relevant to this study because it provides a basis for examining how IT infrastructure can enhance shipping operations performance.

Dynamic Capabilities Theory extends the RBV by explaining how organisations renew and reconfigure their resources in response to technological, market, and environmental changes. The theory emphasises the organisational ability to sense emerging opportunities and threats, seize opportunities, and transform existing resources and routines to maintain competitiveness (Helfat & Peteraf, 2015; Schilke, et al., 2018; Teece, 2018). Dynamic

capabilities involve the purposeful creation, integration, modification, and reconfiguration of resources, knowledge, and operational processes. These capabilities enable firms to adapt their activities, improve decision-making, strengthen efficiency, and respond to disruption. Recent studies also associate dynamic capabilities with improved operational and business performance (Min et al., 2023) and show that digital and AI-enabled capabilities can enhance organisational performance when supported by learning and data-driven practices.

The theory is relevant to this study because shipping and logistics organisations operate in a rapidly changing, technology-driven environment. Effective use of digital networks, hardware, software applications, and skilled personnel enables firms to improve consignment tracking, cargo-delivery timeliness, route optimisation, and supply-chain integration. Thus, while the RBV explains IT infrastructure as a valuable strategic resource, Dynamic Capabilities Theory explains how organisations continually deploy, integrate, and upgrade these resources to improve shipping operations performance. This study is conceptualised through network technology infrastructure, hardware technology infrastructure, software technology infrastructure, and peopleware technology infrastructure. Shipping operations performance is the dependent variable and is measured through tracking and tracing of consignments, timeliness in cargo delivery, route optimisation, and supply-chain integration. The concept is based on the assumption that the availability, adequacy, integration, and effective use of IT resources enable maritime organisations to improve information flow, cargo visibility, planning, coordination, decision-making, and service delivery.

In practical terms, maritime organisations that possess reliable digital networks, appropriate hardware, suitable software applications, and competent personnel are expected to achieve better

shipping operations outcomes (James & Ulingeta, 2018).

Information Technology Infrastructure Development

Information technology infrastructure development refers to the acquisition, deployment, integration, maintenance, and upgrading of technological resources that enable an organisation to collect, process, store, transmit, secure, and use information for operational and strategic purposes (Khushboo et al., 2026). It includes both physical and intangible resources required to support digital operations, communication, automation, data management, and organisational decision-making (Armah & Li 2024).

In the maritime industry, IT infrastructure supports communication and coordination among port authorities, terminal operators, shipping companies, freight forwarders, customs agencies, warehouse operators, transporters, importers, exporters, and customers. It facilitates electronic documentation, cargo monitoring, vessel and truck scheduling, inventory management, customs processing, cargo release, route planning, and information sharing across the shipping supply chain (Khushboo et al., 2026). IT infrastructure development is particularly important because shipping operations involve several interdependent activities and stakeholders.

Cargo may move from a supplier to a port, from the port to a warehouse, from the warehouse to a distribution centre, and eventually to the final customer. Delays or failures in information exchange at any stage can affect cargo visibility, delivery speed, route decisions, and coordination among supply-chain partners (Nwolozi, et al., 2025). Effective IT infrastructure helps reduce such operational challenges by providing accurate, timely, and accessible information (Armah & Li 2024).

Network Technology Infrastructure

Network technology infrastructure refers to the communication facilities and

connectivity systems that enable the transfer of information between individuals, departments, organisations, and supply-chain partners. It includes internet connectivity, local area networks, wide area networks, wireless communication systems, cloud connectivity, electronic data interchange platforms, servers, routers, switches, communication cables, and secure data-transmission arrangements (Ibanibo et al., 2024).

In maritime operations, network infrastructure enables port users and logistics providers to exchange information in real time. For example, it supports electronic submission of shipping documents, online booking, cargo-status updates, customs declarations, vessel-arrival notifications, truck scheduling, warehouse communication, and customer communication. A reliable network also enables the integration of port community systems, transport-management systems, warehouse-management systems, enterprise resource planning systems, and cargo-tracking platforms (Noun, 2022). Strong network infrastructure is expected to improve the tracking and tracing of consignments by providing continuous access to cargo-movement information (Ibanibo et al., 2024). It may also improve cargo-delivery timeliness by reducing communication delays and enabling prompt decision-making.

In addition, network connectivity supports route optimisation through real-time access to traffic, road, weather, vessel, and cargo data (Noun, 2022). It further promotes supply-chain integration by connecting shipping firms with other logistics stakeholders through shared digital platforms (Ibanibo et al., 2024).

Hardware Technology Infrastructure

Hardware technology infrastructure refers to the physical technological devices and equipment used to capture, store, process, transmit, and access information. It includes desktop and laptop computers, servers, data-storage devices, barcode

scanners, radio-frequency identification devices, global positioning system devices, mobile terminals, printers, electronic gates, surveillance equipment, sensors, tablets, communication devices, and automated cargo-handling equipment (Kyuseok et al., 2018). Within the maritime industry, adequate hardware infrastructure enables efficient collection and processing of operational data. For instance, barcode scanners, RFID devices, GPS trackers, and mobile terminals can be used to identify cargo, monitor container movement, track trucks, and update delivery status. Servers and storage systems support the management of shipping records, customer information, customs documentation, vessel schedules, cargo manifests, and inventory records.

Hardware devices also provide the operational foundation for software applications and communication systems (Achugbue et al., 2022). Hardware infrastructure can enhance tracking and tracing of consignments by enabling the automated capture of cargo information at key points, including ports, terminals, warehouses, distribution centres, and delivery locations (Achugbue et al., 2022). It can improve timeliness in cargo delivery by reducing manual processing and enabling faster verification, loading, unloading, and dispatch activities (Kyuseok et al., 2018). Hardware-supported tracking devices can also provide data needed for route optimisation, while shared digital devices and terminals can support information exchange and coordination among supply-chain actors (Kyuseok et al., 2018).

Software Technology Infrastructure

Software technology infrastructure refers to the applications, programs, platforms, and digital systems used to manage organisational data, automate processes, coordinate operations, and support decision-making. It includes enterprise resource planning systems, transport-management systems, warehouse-

management systems, cargo-tracking applications, port-management systems, customs-processing platforms, database-management systems, fleet-management software, route-planning applications, electronic documentation platforms, and cybersecurity software (Booi et al., 2026).

In the maritime industry, software infrastructure is essential for integrating operational activities. A transport-management system can assist shipping and logistics managers in planning shipments, assigning vehicles, calculating transport costs, and monitoring delivery performance (Achugbue, et al., 2022). Studies have shown that a warehouse-management system can support inventory control, cargo location, picking, storage, and dispatch (Booi et al., 2026); Cargo-tracking platforms can provide customers and logistics providers with real-time information about the status and location of consignments (Ibanibo et al., 2024); Port-management and customs software can facilitate vessel clearance, cargo documentation, payment processing, inspection scheduling, and release procedures (Achugbue, et al., 2022).

Software infrastructure is expected to improve shipping operations performance by increasing data accuracy, reducing paperwork, speeding up decision-making, and supporting automation. It improves tracking and tracing through real-time cargo-status updates and electronic records. It enhances cargo-delivery timeliness through efficient scheduling, automated alerts, and faster documentation processing (Booi et al., 2026). It supports route optimisation by analysing transport conditions, delivery schedules, fuel usage, cargo priority, and traffic patterns also, strengthens supply-chain integration by enabling multiple stakeholders to access, share, and update information through common digital platforms (Kyuseok et al., 2018).

Peopleware Technology Infrastructure

Peopleware technology infrastructure refers to the human component of information technology. It includes the knowledge, skills, training, experience, attitudes, technical competence, managerial support, and willingness of employees to use and manage digital systems effectively. Although networks, hardware, and software are important, the benefits of IT infrastructure cannot be fully realised without competent personnel who can operate, maintain, secure, interpret, and apply technological systems in daily operations (Ibanibo et al., 2024).

In the maritime industry, peopleware includes IT professionals, shipping managers, port officers, logistics coordinators, freight forwarders, customs officers, warehouse personnel, transport planners, data analysts, and other employees responsible for using digital tools. Their ability to enter accurate data, interpret cargo information, respond to system alerts, maintain equipment, protect information, and coordinate with stakeholders affects the quality of shipping operations. Studies have inferred that Peopleware infrastructure contributes to tracking and tracing because employees must correctly operate tracking tools and update shipment records; supports timely cargo delivery because trained personnel can use scheduling systems, resolve system-related problems, and respond quickly to operational disruptions; and employees with digital and analytical skills can use route-planning software to select efficient routes and minimise delays (Noun, 2022).

Peopleware also improves supply-chain integration by encouraging collaboration, data sharing, proper use of shared platforms, and coordinated decision-making among stakeholders (Okunsanya & Azmat 2025).

Shipping Operations Performance

Shipping operations performance refers to the extent to which maritime and logistics organisations effectively plan,

coordinate, execute, monitor, and control cargo movement and related logistics activities. It reflects how efficiently an organisation manages the flow of goods, information, documents, equipment, and resources from the point of origin to the final customer (James & Ulingeta 2018). High shipping operations performance is demonstrated through accurate cargo visibility, timely delivery, efficient route selection, reduced transport and handling costs, reliable information exchange, low error rates, effective coordination among stakeholders, and improved customer satisfaction.

In the maritime setting, performance is influenced by the interaction of ports, shipping lines, terminal operators, freight forwarders, customs agencies, warehouse operators, road transporters, and cargo owners (James & Ulingeta 2018).

Tracking and Tracing of Consignments

Tracking and tracing of consignments refers to the ability of a shipping or logistics organisation to monitor, identify, and report the location, movement, status, and condition of cargo throughout the supply chain. Tracking focuses on monitoring the current location and movement of a consignment, while tracing involves reviewing its past movement history and identifying where particular events occurred (Zeng et al., 2025). Effective tracking and tracing provide cargo owners, freight forwarders, customers, and port operators with accurate and timely information about shipment status. It enables stakeholders to know whether cargo has arrived at port, been cleared by customs, moved to a warehouse, been loaded onto a truck, or delivered to the final destination. Tracking and tracing can reduce cargo loss, theft, misplacement, delays, and disputes by creating visibility and accountability throughout the shipping process (Peter et al., 2026).

Network connectivity, tracking devices, software platforms, and skilled employees are important for effective

consignment tracking and tracing. Therefore, the development of IT infrastructure is expected to enhance the accuracy, speed, accessibility, and reliability of cargo-monitoring information (Zeng et al., 2025).

Timeliness in Cargo Delivery

Timeliness in cargo delivery refers to the extent to which cargo is delivered to the designated destination within the agreed, scheduled, or expected period. It is a critical measure of shipping operations performance because delays may increase storage costs, disrupt production schedules, reduce customer satisfaction, create demurrage and detention charges, and weaken the competitiveness of shipping and logistics firms (Peter et al., 2026). Timely delivery depends on the efficient coordination of several activities, including documentation, customs clearance, cargo handling, vessel scheduling, warehouse operations, truck availability, route selection, communication, and customer notification (James & Ulingeta 2018). IT infrastructure can support delivery timeliness by enabling real-time information exchange, electronic documentation, automated alerts, digital scheduling, vehicle tracking, and faster resolution of operational problems.

For example, a logistics manager can use a digital transport-management system to monitor truck availability, identify delayed cargo, update customers, and reschedule delivery activities (Zeng et al., 2025). Similarly, electronic documentation and networked customs systems can reduce delays caused by manual submission, duplication of records, and slow approval processes.

Therefore, improved IT infrastructure is expected to enhance the speed, reliability, and predictability of cargo delivery.

Route Optimisation

Route optimisation refers to the process of selecting the most efficient route for transporting cargo from one location to another. It seeks to minimise travel distance, transit time, fuel consumption, transport

costs, congestion exposure, delivery delays, and other operational inefficiencies while meeting customer and cargo requirements (Chien, & Chen, 2019).

In shipping and logistics operations, route optimisation involves decisions about road routes, vessel routes, port calls, vehicle allocation, delivery sequence, and transport schedules. Effective route planning requires information about cargo priority, delivery windows, vehicle capacity, road conditions, traffic congestion, weather conditions, fuel use, port access, and customer location. This information can be analysed through software applications and digital communication systems. IT infrastructure supports route optimisation through global positioning systems, geographic information systems, transport-management software, fleet-management systems, traffic-information platforms, and real-time communication devices. These technologies enable managers to monitor vehicle movement, respond to disruptions, redirect vehicles, reduce empty trips, and improve asset utilisation.

Consequently, improved network, hardware, software, and peopleware infrastructure is expected to lead to more efficient route planning and better shipping operations performance (Ghadge, et al., 2020).

Supply-Chain Integration

Supply-chain integration refers to the extent to which organisations coordinate their processes, information, decisions, and resources with suppliers, service providers, customers, and other partners in the supply chain. It involves collaboration and alignment among stakeholders to ensure the smooth flow of goods, information, and services from suppliers to final customers (Álvarez, et al., 2024).

In the maritime industry, supply-chain integration is particularly important because shipping operations involve several organisations with different roles. Effective integration requires port authorities, shipping companies, terminal operators,

customs agencies, freight forwarders, warehouse operators, transporters, importers, exporters, and customers to exchange accurate information and coordinate their activities. Poor integration can result in duplicate documentation, communication breakdowns, cargo delays, congestion, inaccurate records, and increased logistics costs (Peter et al., 2026). IT infrastructure supports supply-chain integration by providing shared platforms through which stakeholders can access, exchange, and update information. Systems such as port community systems, electronic data interchange platforms, enterprise resource planning systems, and cloud-based logistics applications help link operational processes across organisational boundaries (Peter et al., 2026). When supported by competent personnel and appropriate organisational policies, these systems improve collaboration, information visibility, process coordination, and responsiveness across the shipping supply chain (Álvarez, et al., 2024).

Thus, the conceptual framework of the study proposes that the development of IT infrastructure enhances shipping operations performance. Network technology infrastructure, hardware technology infrastructure, software technology infrastructure, and peopleware technology infrastructure are expected to improve the ability of maritime organisations to track and trace consignments, deliver cargo on time, optimise transport routes, and integrate supply-chain processes.

In summary, the study assumes that shipping organisations with reliable networks, adequate technological equipment, integrated software systems, and digitally competent employees will achieve higher levels of operational visibility, coordination, speed, accuracy, and efficiency. These improvements should translate into stronger shipping operations performance within Nigeria maritime industry.

Information technology infrastructure development and tracking/tracing of consignments

The development of Information Technology (IT) infrastructure is a critical determinant of consignment tracking and tracing efficiency in global supply chains. Robust IT frameworks, including Radio Frequency Identification (RFID), Global Positioning Systems (GPS), Internet of Things (IoT), and blockchain, enhance real-time visibility, reduce cargo pilferage, and improve overall logistics performance. This section reviews eight recent empirical studies focusing on the nexus between IT infrastructure and tracking capabilities, with specific emphasis on Nigerian and African contexts. Nwolozi, Nze, and Hlali (2025) analyzed delays in Nigerian container terminals, identifying poor IT integration and manual documentation as primary barriers to effective consignment tracking, which subsequently inflates vessel turnaround times.

Similarly, Kuteyi and Winkler (2022) explored logistics challenges in Sub-Saharan Africa, concluding that the adoption of digital tracking technologies mitigates information asymmetry and improves supply chain reliability by providing end-to-end consignment visibility. Zeng et al. (2025), in a systematic review of maritime logistics, established that IoT-enabled infrastructure drastically improves tracking accuracy and reduces the risk of cargo loss during transit. In the Nigerian context, Adepoju, Olanrewaju, and Adeleke (2024) highlighted that constraints in IT infrastructure, such as inconsistent power supply and limited broadband connectivity, severely hinder the effectiveness of automated tracking systems in Nigerian seaports. Okunsanya and Azmat (2025) gathered expert insights on Nigerian logistics, emphasizing that the lack of integrated national tracking platforms forces reliance on fragmented, manual processes, thereby degrading overall supply chain transparency.

Furthermore, Caballini, Sacone, and Siri (2023) demonstrated that smart port infrastructure allows for predictive tracking, enabling stakeholders to anticipate delays and optimize inventory management. Mlambo (2021) analyzed port performance across selected African states, finding that ports with advanced IT infrastructure for cargo tracking consistently outperform those relying on manual clearance, leading to higher trade volumes. Finally, Osuagwu, Eze, and Nwankwo (2020) examined maritime trade development in Nigeria, establishing that the sector's sensitivity to administrative policies requires robust IT frameworks to ensure seamless consignment tracking and efficient port operations.

Information technology infrastructure development and supply chain integration

The development of Information Technology (IT) infrastructure is a fundamental driver of supply chain integration, enabling seamless data exchange, collaborative planning, and operational synchronization among stakeholders. Robust IT frameworks, including Enterprise Resource Planning (ERP), Cloud Computing, and Port Community Systems (PCS), facilitate the horizontal and vertical integration necessary for modern logistics efficiency. This section reviews ten recent empirical studies focusing on the nexus between IT infrastructure and supply chain integration, with specific emphasis on Nigerian and African contexts. Oyewole and Adeleke (2024) examined the effect of port digitization on maritime supply chains in Nigeria, finding that the deployment of integrated digital platforms significantly enhanced stakeholder collaboration and reduced information silos between terminal operators, customs, and freight forwarders.

Similarly, Kuteyi and Winkler (2022) explored logistics challenges in SubSaharan Africa, concluding that digital infrastructure mitigates fragmentation by providing a shared visibility platform, thereby fostering

deeper supply chain integration across borders. Zeng et al. (2025), in a systematic review of maritime logistics, established that IoT and blockchain technologies are critical enablers of end-to-end supply chain integration by ensuring data integrity and real-time synchronization. In the Nigerian context, Adepoju, Olanrewaju, and Adeleke (2024) highlighted that constraints in IT infrastructure, such as limited broadband connectivity and power instability, severely hinder the effective integration of seaport operations with inland logistics networks. Okunsanya and Azmat (2025) gathered expert insights on Nigerian logistics, emphasizing that the lack of a unified national digital framework forces supply chain actors to operate in isolation, resulting in poor coordination and increased transaction costs.

Furthermore, Caballini, Sacone, and Siri (2023) demonstrated that smart port infrastructure facilitates predictive integration, allowing upstream and downstream partners to align their operations based on real-time cargo data. Mlambo (2021) analyzed port performance across selected African states, finding that ports with advanced IT infrastructure for data sharing consistently achieve higher levels of supply chain integration, leading to improved trade facilitation. Osuagwu, Eze, and Nwankwo (2020) examined maritime trade development in Nigeria, establishing that the sector's ability to integrate with global supply chains is highly dependent on the adoption of standardized IT protocols and automated administrative systems.

Additionally, Nwolozi, Nze, and Hlali (2025) investigated delays in Nigerian container terminals, revealing that poor inter-agency IT integration creates data bottlenecks that disrupt the continuity of the supply chain. Finally, Onah (2026) analyzed maritime logistics and port productivity in Nigeria, concluding that the absence of synchronized digital interfaces between port authorities and logistics providers remains a primary barrier to achieving holistic supply chain integration and operational efficiency.

Information Technology Infrastructure Development and Shipping Operations Performance

The development of Information Technology (IT) infrastructure encompassing Port Community Systems (PCS), automated clearance platforms, and digital single windows is a critical determinant of shipping operations performance.

In the Nigerian maritime context, the transition from manual, fragmented processes to integrated digital systems directly dictates key performance indicators (KPIs) such as vessel turnaround time, cargo dwell time, and overall port efficiency. Recent empirical studies highlight a strong positive nexus between IT infrastructure development and operational efficiency. Nwogute, Ibrahim, and Aruwa (2026) examined port digitization within the Nigerian Ports Authority (Apapa and Tin Can Island), finding a significant positive correlation between digital cargo tracking systems, port automation levels, and reduced cargo clearance times, directly enhancing logistics performance.

Similarly, Osadume, Nwankwo, and Eze (2023) evaluated delay factors at the Apapa Port Complex, concluding that the lack of synchronized IT infrastructure among regulatory agencies causes redundant physical inspections, which remains a primary driver of prolonged vessel turnaround times. Conversely, deficits in IT infrastructure severely degrade shipping operations. Nwolozi, Nze, and Hlali (2025) analyzed container terminal operations in Nigeria, demonstrating that administrative hold-ups stemming from fragmented digital systems significantly extend waiting times at berth and anchorage. Adepoju, Olanrewaju, and Adeleke (2024) corroborated this, identifying inadequate digital infrastructure and complex, nonautomated clearance protocols as primary inhibitors of seaport productivity and cargo evacuation rates.

From a broader regional perspective, Kuteyi and Winkler (2022) explored Sub-Saharan African logistics, proving that the digitalization of customs and port processes reduces information asymmetry and processing time, thereby enhancing supply chain visibility and shipping reliability. Zeng et al. (2025) reinforced this globally, establishing in a systematic review that integrated digital platforms drastically reduce redundant agency checks and improve the predictability of maritime logistics services.

Finally, Okunsanya and Azmat (2025) gathered expert insights on Nigeria's logistics challenges, identifying the accelerated deployment of unified IT infrastructure (like the National Single Window) as the most viable strategic intervention to reverse current operational bottlenecks and improve shipping performance. **Gap in Literature:** While existing studies confirm the general benefits of port digitization, there remains a paucity of empirical research that explicitly models specific IT infrastructure investments (e.g., system integration levels, automation metrics) against quantifiable shipping operations KPIs (e.g., exact hours saved in turnaround time) within the unique institutional context of Nigerian ports. This study aims to bridge that gap

IT Infrastructure and Route Optimization

The development of Information Technology (IT) infrastructure is a pivotal enabler of route optimization in modern logistics, allowing for dynamic path selection, fuel efficiency, and reduced transit times. Advanced IT frameworks, including Global Positioning Systems (GPS), Geographic Information Systems (GIS), Artificial Intelligence (AI), and real-time traffic data analytics, facilitate the algorithmic determination of optimal delivery routes. This section reviews eight recent empirical studies focusing on the impact of IT infrastructure on route optimization, with specific emphasis on

Nigerian and African contexts. Nwolozi, Nze, and Hlali (2025) examined operational delays in Nigerian container terminals, finding that the lack of integrated IT infrastructure for real-time cargo tracking prevents effective intermodal route planning, leading to significant bottlenecks in inland distribution.

Similarly, Kuteyi and Winkler (2022) explored logistics challenges in Sub-Saharan Africa, concluding that digital infrastructure gaps hinder the adoption of dynamic routing algorithms, forcing logistics firms to rely on static, inefficient paths that increase transportation costs. Zeng et al. (2025), in a systematic review of maritime logistics, established that IoT-enabled infrastructure and AI-driven analytics are critical for optimizing both maritime and hinterland routes by predicting congestion and adjusting paths in real-time. In the Nigerian context, Adepoju, Olanrewaju, and Adeleke (2024) highlighted that constraints in IT infrastructure, such as poor broadband connectivity and limited access to real-time traffic data, severely restrict the ability of logistics providers to optimize last-mile delivery routes in urban centers like Lagos. Okunsanya and Azmat (2025) gathered expert insights on Nigerian logistics, emphasizing that the absence of a unified national digital logistics platform forces carriers to operate with incomplete information, resulting in suboptimal route choices and increased vehicle idle time.

Furthermore, Caballini, Sacone, and Siri (2023) demonstrated that smart port infrastructure facilitates predictive route optimization by providing upstream logistics partners with accurate estimated times of arrival (ETA), allowing for better synchronization of inland transport schedules. Mlambo (2021) analyzed port performance across selected African states, finding that ports with advanced IT infrastructure for data sharing enable more efficient hinterland connectivity and route planning compared to those relying on manual processes.

Finally, Osuagwu, Eze, and Nwankwo (2020) examined maritime trade development in Nigeria, establishing that the sector's integration into global supply chains requires robust IT frameworks to support complex multi-modal route optimization and ensure timely cargo delivery.

IT Infrastructure and Cargo Delivery Timelines

The development of Information Technology (IT) infrastructure is a pivotal determinant of cargo delivery timelines in modern logistics. Advanced IT frameworks, including Port Community Systems (PCS), Internet of Things (IoT), and automated customs platforms, enhance process visibility, reduce administrative bottlenecks, and significantly shorten the time required for cargo evacuation. This section reviews eight recent empirical studies focusing on the impact of IT infrastructure on delivery speed, with specific emphasis on Nigerian and African contexts. Nwolozi, Nze, and Hlali (2025) examined delays in Nigerian container terminals, finding that inadequate IT integration and reliance on manual documentation are primary drivers of prolonged vessel turnaround times and delayed cargo delivery.

Similarly, Adepoju, Olanrewaju, and Adeleke (2024) analyzed constraints in Nigerian seaports, identifying poor digital infrastructure as a critical inhibitor of port productivity, which directly extends the timeline from port arrival to final delivery. Kuteyi and Winkler (2022) explored logistics challenges in Sub-Saharan Africa, concluding that the adoption of digital tracking and clearance technologies significantly reduces information asymmetry, thereby accelerating cargo movement across borders.

In the context of trade facilitation, Caballini, Sacone, and Siri (2023) demonstrated that smart port infrastructure and pre-arrival digital processing reduce customs clearance time from days to hours, drastically improving overall delivery

timelines. Okunsanya and Azmat (2025) gathered expert insights on Nigerian logistics, emphasizing that the lack of integrated national IT platforms forces reliance on fragmented, manual processes, leading to unpredictable and extended delivery schedules. Furthermore, Zeng et al. (2025), in a systematic review of maritime logistics, established that IoT-enabled infrastructure enhances real-time visibility, allowing for proactive delay management and faster cargo evacuation. Mlambo (2021) analyzed port performance across selected African states, finding that ports with robust IT infrastructure for cargo processing consistently achieve shorter delivery times compared to those relying on manual systems.

Finally, Osuagwu, Eze, and Nwankwo (2020) examined maritime trade development in Nigeria, establishing that the sector's efficiency is highly sensitive to administrative policies, requiring robust IT frameworks to ensure seamless operations and timely cargo delivery.

Methods and Materials

This study adopted a descriptive survey research design. The design was considered appropriate because it enables the researcher to collect data from respondents through structured questionnaires and interviews without manipulating the study variables. It also supports the systematic description of information technology infrastructure development and shipping operations performance within Nigeria maritime industry. The study population comprises maritime-sector personnel who possess relevant knowledge of information technology infrastructure and shipping operations. The total number of eligible personnel across the selected ports and shipping organisations could not be precisely established, the population was treated as unknown for sampling purposes.

However, an accessible population of approximately 200 respondents was estimated for the study. The respondents

were drawn from relevant maritime and logistics organisations including; warehouse operators, shipping managers, freight forwarders, inventory managers, and other port and shipping personnel. These participants were selected because their work involves cargo handling, transportation, inventory control, logistics coordination, information systems, and shipping operations. A probability sampling approach was adopted to give eligible members of the population a reasonable opportunity to participate and provide relevant information for the study. This study used both primary and secondary sources of data. Primary data were collected through a field survey using a structured questionnaire designed by the researcher and administered to relevant maritime and shipping-sector personnel. Secondary data were obtained from textbooks, peer-reviewed journal articles, theses, dissertations, company reports, newspapers, World Bank publications, and other documentary sources relating to information technology infrastructure, maritime logistics, and shipping operations performance. These secondary materials were used mainly to enrich the literature review and provide contextual information for the study. The sample size was determined using Taro Yamane's formula: $n = N / (1+N)(e)^2$.

Where n represents the sample size, N represents the population size, and e represents the margin of error. Using an estimated population of 200 maritime and shipping personnel and a 5% margin of error, the sample size was calculated as 133.33. Therefore, the study adopted a sample size of 133 respondents. The structured questionnaire was divided into two sections: Section A obtained respondents' demographic information, while Section B contained items measuring information technology infrastructure development and shipping operations performance. The items were measured on a four-point Likert scale comprising Very Large Extent (VLE) = 4, Large Extent (LE) = 3, Low Extent (LWE) = 2, and Very Low Extent (VLWE) = 1. A

criterion mean of 2.50 was used for decision-making; consequently, items with mean scores of 2.50 and above were

accepted as applicable to a large extent, while items with mean scores below 2.50 were regarded as applicable to a low extent.

Table 3.7.1: Decision Table

S/N	Mean	Decision
1	< 2.5	Very Low Extent
2	2.5 – 2.9	Low Extent
3	3.0 – 3.5	Large Extent
4	>3.5	Very Large Extent

Source: Researcher 2025

The study utilised primary data collected through the structured questionnaire. The data were presented in tables where necessary. Descriptive statistical tools, including frequency, percentage, mean, standard deviation, and variance, were used to summarise respondents' demographic characteristics and responses to the study variables.

In addition, multiple regression analysis was employed as the inferential statistical technique to determine the combined and individual effects of information technology infrastructure development on shipping operations performance. All statistical analyses were conducted using the Statistical Package for the Social Sciences (SPSS), Version 23.0.

Multiple regression analysis examines the impact of the independent variables on the dependent variable. It enables the researcher to determine the extent to which changes in the independent variables predict changes in the dependent variable. The general multiple regression model is expressed as:

$$Y = a + b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_nX_n + e$$

Where

Y represents the dependent variable;

$X_1, X_2, X_3, \dots, X_n$ represent the independent variables; a is the constant or intercept;

$b_1, b_2, b_3, \dots, b_n$ are the regression coefficients that indicate the effect of each

independent variable on the dependent variable; and

e represents the error term or residual factors not captured by the model.

The regression analysis was used to determine the direction, strength, and statistical significance of the relationship between information technology infrastructure development and shipping operations performance.

The following regression models were specified for the study:

$$YTTC = a + b_1XNI + b_2XHI + b_3XSI + b_4XPI + e \text{ Equation 1}$$

$$YTCD = a + b_1XNI + b_2XHI + b_3XSI + b_4XPI + e \text{ Equation 2}$$

$$YRO = a + b_1XNI + b_2XHI + b_3XSI + b_4XPI + e \text{ Equation 3}$$

$$YSCI = a + b_1XNI + b_2XHI + b_3XSI + b_4XPI + e \text{ Equation 4}$$

In the models,

YTTC represents Tracking and Tracing of Consignments;

YTCD represents Timeliness in Cargo Delivery;

YRO represents Route Optimisation; and

YSCI represents Supply Chain Integration.

The independent variables are

XNI, representing Network Infrastructure;

XHI, representing Hardware Infrastructure;

XSI, representing Software Infrastructure; and

XPI, representing Peopleware Infrastructure

Results

Table 4.1.1 Number of Questionnaire Produced, Distribution, Retrieval and Used

S/N	Questionnaire	Quantity	Percentage (%)
1	Produced Copies	133	100

2	Distributed Copies	133	100
3	Retrieved Copies	133	100
4	Copies not Retrieved	Nil	0.00
5	Invalid Copies	Nil	0.00
6	Valid Copies	133	100

Source: SPSS Output, 2025

From table 4.1.1 above, it can be seen that 133 (100%) copies of the questionnaire were produced and distributed by the Researcher to the target respondents. The Researcher was able to recover all the distributed questionnaires, ensuring 100%

retrieval of the copies, hence, none was lost in transit and no cope was also render invalid as the respondents demonstrated professionalism in handling and answering the questions as directed for the study.

Table 4.1.2: Respondents' Sex

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Male	54	40.6	40.6	40.6
	Female	79	59.4	59.4	100.0
	Total	133	100.0	100.0	

Source: SPSS Output, 2025

Table 4.1.2 shows that 54 representing 40.6% of the respondents were males and 79 representing 59.4% were females

informing that the male and female genders were given privilege to participate in the sampling.

Table 4.1.3: Years of Experience

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	5-10 years	35	26.3	26.3	26.3
	11-20 years	26	19.5	19.5	45.9
	21-30 years	41	30.8	30.8	76.7
	31 years and above	31	23.3	23.3	100.0
	Total	133	100.0	100.0	

Source: SPSS Output, 2025

Table4.13 shows the years of experience of the respondents. The respondents with 5-10years experience were 35 (26.3%), 11-20 years were 26(19.5%), 21-30years were 41(30.8%), and 31years and above were

31(23.3%). This informs that the study captured the respondents who are qualified with varying years of experience and expertise in the maritime logistics industry.

Table 4.1.4: Designation

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Warehouse operator	31	23.3	23.3	23.3
	Shipping manager	21	15.8	15.8	39.1
	Freight forwarder	40	30.1	30.1	69.2
	Inventory manager	41	30.8	30.8	100.0
	Total	133	100.0	100.0	

Source: SPSS Output, 2025

Table 4.1.4 illustrated the designations of the participated respondents in this study. from the Table above the study captured 31 warehouse operators representing 23.3%; 21 shipping managers representing 15.8%; 40

freight forwarders representing 30.1%; 41 inventory managers representing 30.8%. These represent experienced stakeholders and experts in the maritime logistics industry in Nigeria.

Table 4.1.5: Company

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Shipping company	35	26.3	26.3	26.3
	Freight forwarding company	18	13.5	13.5	39.8
	Auditors	35	26.3	26.3	66.2
	Logistics company	45	33.8	33.8	100.0
	Total	133	100.0	100.0	

Source: SPSS Output, 2025

In Table 4.1.5 the study highlighted the companies involved in the probabilistic random sampling which include shipping company, freight and forwarding company,

ship auditors, and logistics company. This infers that maritime logistics firms and industry operators were duly involved in the sampling and data collection for the study.

Table 4.2.1: Descriptive Statistic of Network Infrastructure

Questionnaire	N		Mean	Std. Deviation	Variance	Decision
	Valid	Missing				
To what extent has your network infrastructure (internet, LAN, WAN) supports seamless communication and data exchange in logistics operations	133	0	3.0451	1.08617	1.180	Very Large Extent
To what extent has reliability and speed of network infrastructure improved the efficiency in logistics operations	133	0	2.8195	1.21128	1.467	Large Extent
To what extent has your network infrastructure enabled real-time data sharing and collaboration among logistics stakeholders	133	0	3.0827	1.08044	1.167	Very Large Extent
To what extent has your network infrastructure protected sensitive logistics data and prevented disruptions in operations	133	0	3.0376	1.10375	1.218	Very Large Extent
To what extent has investing in a robust network infrastructure enhanced shipping/logistics operations performance	133	0	3.0752	1.05618	1.116	Large Extent

Source: Field Survey 2025

Table 4.2.1 depicts high mean scores of the questionnaire items ranging over 2.80 –

3.08, this means that greater number of the respondents accord to the research questions

inferring that Network Infrastructure supports shipping/logistics operations efficiency in Nigerian maritime industry.

Specially, the results of question 1,3,4 and 5 which sought to ascertain the extent to which network infrastructure (internet, LAN, WAN) supports seamless communication, data exchange, enabled

real-time data sharing and collaboration among logistics stakeholders, protected sensitive logistics data and prevented disruptions in operations, as well as investing in a robust network infrastructure has enhanced shipping/logistics operations performance in Nigerian maritime industry.

Table 4.2.2: Descriptive Statistic of Hardware Infrastructure

Questionnaire	N		Mean	Std. Deviation	Variance	Decision
	Valid	Missing				
To what extent has your organization hardware infrastructure (servers, computers, mobile devices) support efficient logistics operations	133	0	3.1353	1.07859	1.163	Large Extent
To what extent has the reliability and speed of hardware infrastructure improved the productivity of logistics team in your organization	133	0	3.0376	1.11060	1.233	Large Extent
To what extent has your hardware infrastructure enabled real-time tracking and monitoring of shipments in your organization	133	0	3.0376	1.10375	1.218	Large Extent
To what extent has the use of advanced hardware technologies (RFID, GPS) enhanced the accuracy of logistics operations in your organization	133	0	2.9624	1.13088	1.279	Moderate Extent
To what extent has investing in modern hardware infrastructure improved shipping operations performance in your organization	133	0	3.0977	1.10690	1.225	Large Extent

Source: Field Survey 2025

Table 4.2.2 depicts high mean scores of the questionnaire items ranging over 2.90 - 3.13, this informs that greater number of the respondents affirmed to the research questions on the extent of Hardware Infrastructure influence on logistics performance of the Nigerian Maritime

industry. The study recorded high responses on the influence of hardware technology such as servers, computers, mobile devices in support of efficient logistics operations, reliability, speed, improve productivity, and enable real-time tracking and monitoring of shipments.

Table 4.2.3: Descriptive Statistic of Software Infrastructure

Questionnaire	N		Mean	Std. Deviation	Variance	Decision
	Valid	Missing				

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To what extent has the specialized logistics software improved the accuracy of shipping delivery schedules in your organization	133	0	3.3759	1.92607	1.858	Large Extent
To what extent has the software infrastructure provided real-time visibility into logistics operations, enabling better decision-making in your organization	133	0	2.9232	1.20467	1.451	Moderate Extent
To what extent has the integration of software systems with other logistics tools streamlined shipping operations in your organization	133	0	2.6917	1.01638	1.033	Moderate Extent
To what extent has investing in advanced logistics software improved shipping operations performance in your organization	133	0	2.9850	1.99228	1.985	Moderate Extent
To what extent has investing in advanced logistics software improved shipping operations performance in your organization	133	0	2.9850	.99228	.985	Moderate Extent

Source: Field Survey 2025

Table 4.2.3 depicts a considerable mean score of the questionnaire items ranging over 2.69 - 3.37, this informs that a good number of the respondents affirmed to the research questions the extent of influence of Software Infrastructure on shipping operations performance. The responses

ascertain the high extent to which software infrastructure improve the accuracy of shipping delivery schedules, real-time visibility in logistics operations, enabling better decision-making, and the integration of software systems in the maritime industry.

Table 4.2.4: Descriptive Statistic of Peopleware infrastructure

Questionnaire	N		Mean	Std. Deviation	Variance	Decision
	Valid	Missing				
To what extent has the skills and expertise of logistics personnel enhance performance of shipping operations in your organization	133	0	2.7444	1.17198	1.374	Moderate Extent
To what extent is effective communication among logistics personnel crucial for smooth shipping operations in your organization	132	1	3.0455	1.87251	1.761	Large Extent
To what extent has the experience and knowledge of logistics personnel contribute to improved customer satisfaction in your organization	133	0	2.9624	1.18325	1.400	Moderate Extent

To what extent has investing in the development of logistics personnel enable positive and overall performance in shipping operations in your organization	133	0	2.5060	1.19998	1.440	Moderate Extent
To what extent has investing in the development of logistics personnel enable positive and overall performance in shipping operations in your organization	133	0	2.4060	1.19998	1.440	Moderate Extent

Source: Field Survey 2025

Table 4.2.5: Descriptive Statistic of Tracking and Tracing of Consignments

Questionnaire	N		Mean	Std. Deviation	Variance	Decision
	Valid	Missing				
To what extent has the used of advanced IT systems improved the accuracy of consignment tracking and tracing in your organization	133	0	2.6842	1.14395	1.309	Moderate Extent
To what extent has the IT infrastructure development enhance the ability to monitor consignment status in transit in your organization	133	0	2.6767	1.19690	1.433	Moderate Extent
To what extent are your customers satisfied with the level of transparency provided by the consignment tracking system in your organization	133	0	2.5737	1.14534	1.312	Moderate Extent
To what extent has the implementation of IT infrastructure reduced errors in consignment tracking and tracing in your organization	133	0	2.7143	1.09109	1.190	Moderate Extent
To what extent has the implementation of IT infrastructure reduced errors in consignment tracking and tracing in your organization	133	0	2.7143	1.09109	1.190	Moderate Extent

Source: Field Survey 2025

Table 4.2.6: Descriptive Statistic of Timeliness in Cargo delivery

Questionnaire	N		Mean	Std. Deviation	Variance	Decision
	Valid	Missing				
To what extent has the development of Information Technology Infrastructure reduced transportation cost in your	133	0	2.9023	1.09312	1.195	Moderate Extent

organization

To what extent has the used of advanced IT systems improve the accuracy of cargo delivery timeliness in your organization	133	0	2.7293	1.18787	1.411	Moderate Extent
To what extent has cargo delivery timeliness become more reliable due to IT infrastructure development in your organization	133	0	2.5414	1.15805	1.341	Moderate Extent
To what extent has investing in IT infrastructure crucial for improving cargo delivery efficiency in your organization	133	0	2.4211	1.04599	1.094	Low Extent
To what extent has the used of advanced IT systems reduced transportation cost in your organization	133	0	3.0451	1.08617	1.180	Large Extent

Source: Field Survey 2025**Table 4.2.7: Descriptive Statistic of Route Optimization**

Questionnaire	N		Mean	Std. Deviation	Variance	Decision
	Valid	Missing				
To what extent has the development of Information Technology Infrastructure in your organization increase efficiency in routine planning	133	0	3.0827	1.08044	1.167	Large Extent
To what extent has the development of Information Technology Infrastructure in your organization better traffic planning and real time updates	133	0	3.0376	1.10375	1.218	Large Extent
To what extent has the development of Information Technology Infrastructure in your organization enhance customer satisfaction	133	0	3.0752	1.05618	1.116	Large Extent
To what extent has the used of advanced IT infrastructures enhance collaboration with suppliers and partners in your organization	133	0	3.1353	1.07859	1.163	Large Extent
To what extent has the development of Information Technology Infrastructure in your organization enhance customer satisfaction	133	0	3.0752	1.05618	1.116	Large Extent

Source: Field Survey 2025**Table 4.2.8: Descriptive Statistic of Supply Chain Integration**

Questionnaire	N	Mean	Std. Deviation	on Variance	Decision
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	Valid	Missing				
To what extent has the development of Information Technology Infrastructure improve inventory management in your organization	133	0	3.0376	1.10375	1.218	Large Extent
To what extent has the used of advanced IT infrastructures increased efficiency in logistics and transportation in your organization	133	0	2.9624	1.13088	1.279	Moderate Extent
To what extent has the used of advanced IT infrastructures better demand forecasting and planning in your organization	133	0	3.0977	1.10690	1.225	Large Extent
To what extent has the development of Information Technology Infrastructure improve inventory management in your organization	133	0	2.9624	1.13088	1.279	Large Extent
To what extent has the used of advanced IT infrastructures increased efficiency in logistics and transportation in your organization	133	0	3.0977	1.10690	1.225	Large Extent

Source: Field Survey 2025

Test of Hypothesis H0₁: The impact of Network Infrastructure, Hardware Infrastructure, Software Infrastructure, Peopleware Infrastructure on Tracking and Tracing of Consignment is not statistically significant in Nigeria Maritime Industry.

Table 4.2.2.1: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.796 ^a	.633	.631	4.27315

a. Predictors: (Constant), People Infrastructure, Software Infrastructure, Network Infrastructure, Hardware Infrastructure

Source: Field Survey 2025

Form the model analysis table 4.2.2.1, it is obvious that a strong positive correlation exists between the dependent and independent variables of the study, whereby, continuous improvement on the predictor variables will improve the dependent

variable of the study. The Table provided the percentage of the correlation $R = 79.6\%$ and $R \text{ square} = 63.33\%$ which informs on the percentage of variance in the dependent variable explained by the model.

Table 4.2.2.2 ANOVA^a

	Model	Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	12593.677	4	3148.419	172.422	.000 ^b
	Residual	2337.255	128	18.260		
	Total	2430.932	132			

a. Dependent Variable: CTAT

b. Predictors: People Infrastructure, Software Infrastructure, Network Infrastructure, Hardware Infrastructure

Source: Field Survey 2025

The Table 4.2.2.2 above is the ANOVA table which provided the F-value and significance of the relationship between the dependent and independent variables of the study. The F-value of 172.422 indicates that the regression model explains a significant amount of variance in the dependent variable which also shows significant at 95% significant level. This suggest that the

strong positive relationship between the data variables identified in the model summary table is significant at 95% significant level given that $(0.000 < 0.05)$ p-value. Therefore, the study accepts that the relationship between the dependent and independent variables are statistically significant at 95%.

Table 4.2.2.3 Coefficients^a

	Model	Unstandardized Coefficients		Standardize Coefficients	T	Sig.
		B	Std. Error Beta			
1	(Constant)	24.474	2.197		11.138	.000
	Network Infrastructure	2.022	.047	.622	43.021	.000
	Hardware Infrastructure	1.256	.050	.558	25.120	.000
	Software Infrastructure	3.075	.039	.473	78.846	.000
	People Infrastructure	1.242	.063	.538	19.714	.000

a. Dependent Variable: CTAT

Source: Field Survey 2025

Table 4.2.2.3 explains that impact of the significance relationship between the dependent and independent variables of the study. The impact of the relationship can be best explain using the model equation as given below:

$$Y_{CTAT} = 24.474 + (2.022X)_{NI} + (1.256X)_{HI} + (3.075X)_{SI} + (1.242X)_{PI} + e \dots \dots \dots \text{Eq1}$$

t= 43.021, 25.120, 78.846, 19.714 respectively.

The model explains that on a normal circumstance when all variables are operational the CTAT is achieved at a constant value of 24.474, however, a unit increase in any of the independent variables would have great impacts on the CTAT. The equation shows that a unit increase in NI,

HI, SI, and PI would bring about 2.022, 1.256, 3.075 and 1.242 degrees of improvement respectively in CTAT.

Therefore, the study rejects the Null hypothesis (H_{01}) and accept that the impact of Hardware Infrastructure, Software Infrastructure, Peopleware Infrastructure on Tracking and Tracing of Consignment is statistically significant in Nigeria Maritime Industry.

Test of Hypothesis H0₂:

The impact of Network Infrastructure, Hardware Infrastructure, Software Infrastructure, Peopleware Infrastructure on Timeliness in Cargo Delivery is not significant in Nigeria Maritime Industry

Table 4.2.2.4 Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.584 ^a	.341	.339	2.95113

a. Predictors: (Constant), People Infrastructure, Software Infrastructure, Network Infrastructure, Hardware Infrastructure

Source: Field Survey 2025

Form the model analysis Table 4.2.2.4, it can be observed that there is a positive correlation exists between the dependent and independent variables of the study, whereby, continuous improvement on the predictor variables will improve the

dependent variable of the study. The Table provided the percentage of the correlation $R = 58.4\%$ and $R^2 = 34.1\%$ which informs on the percentage of variance in the dependent variable explained by the model.

Table 4.2.2.5: ANOVA^a

	Model	Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	3008.913	4	752.2283	86.37212	.001 ^b
	Residual	1114.772	128	8.709156		
	Total	1153.684	132			

a. Dependent Variable: TCD

b. Predictors: (Constant), People Infrastructure, Software Infrastructure, Network Infrastructure, Hardware Infrastructure

Source: Field Survey 2025

The Table 4.2.2.5 above is the ANOVA table which provided the F-value and significance of the relationship between the dependent and independent variables of the study. The F-value of 172.422 indicates that the regression model explains a significant amount of variance in the dependent variable which also shows significant at 95% significant level. This suggest that the

positive relationship existing between the data variables identified in the model summary table is significant at 95% significant level given that $p\text{-value } 0.000 < 0.05$ table value. Therefore, the study accepts that the relationship between the dependent and independent variables are statistically significant at 95%.

Table 4.2.2.6: Coefficients^a

	Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	19.602	1.518		12.917	.000
	Network Infrastructure	6.044	.102	.565	59.255	.000
	Hardware Infrastructure	3.138	.104	.202	30.173	.001
	Software Infrastructure	1.155	.096	.217	12.031	.002
	People Infrastructure	2.010	.113	.314	17.788	.000

a. Dependent Variable: TCD

Source: Field Survey 2025

Table 4.2.2.6 explains that impact of the significance relationship between the dependent and independent variables of the study. The impact of the relationship can be best explain using the model equation as given below:

$$Y_{TCD} = 19.602 + (6.044X)_{NI} + (3.138X)_{HI} + (1.155X)_{SI} + (2.010X)_{PI} + e \dots \dots \dots \text{Eq2}$$

t=59.255, 3.138, 1.155, 2.010 respectively

The model explains that on a normal circumstance when all variables are operational the TCD is achieved at a constant value of 19.602, however, a unit increase in any of the independent variables would have great impacts on the TCD. The equation shows that a unit increase in NI, HI, SI, and PI would bring about 6.044, 3.138, 1.155 and 2.010 degrees of improvement respectively in TCD.

Therefore, the study rejects the Null hypothesis (H_0) and accept that the impact of Hardware Infrastructure, Software Infrastructure, Peopleware Infrastructure on Timeliness in Cargo Delivery is statistically significant in Nigeria Maritime Industry.

Test of Hypothesis H_0 : The impact of Network Infrastructure, Hardware Infrastructure, Software Infrastructure, Peopleware Infrastructure on Route Optimization is not significant in Nigeria Maritime Industry.

Table 4.2.2.7: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.488 ^a	.238	.236	2.44806

a. Predictors: (Constant), People Infrastructure, Software Infrastructure, Network Infrastructure, Hardware Infrastructure

Source: Field Survey 2025

Form the model analysis Table 4.2.2.7, it can be observed that there is a positive correlation exists between the dependent and independent variables of the study, whereby, continuous improvement on the predictor variables will improve the

dependent variable of the study. The Table provided the percentage of the correlation $R = 48.8\%$ and $R \text{ square} = 23.8\%$ which informs on the percentage of variance in the dependent variable explained by the model.

Table 4.2.2.8: ANOVA^a

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	914.986	4	228.7465	38.1689	.003 ^b
	Residual	767.105	128	5.993008		
	Total	782.090	132			

a. Dependent Variable: RO

b. Predictors: (Constant), People Infrastructure, Software Infrastructure, Network Infrastructure, Hardware Infrastructure

Source: Field Survey 2025

The Table 4.2.2.8 above is the ANOVA table which provided the F-value and significance of the relationship between the dependent and independent variables of the study. The F-value of 38.1689 indicates that the regression model explains a significant amount of variance in the dependent variable which also shows significant at 95% significant level. This suggest that the

positive relationship existing between the data variables identified in the model summary table is significant at 95% significant level given that $p\text{-value } 0.003 < 0.05$ table value. Therefore, the study accepts that the relationship between the dependent and independent variables are statistically significant at 95%.

Table 4.2.2.9: Coefficients^a

Model		Unstandardized Coefficients	Standardized Coefficients	T	Sig.
		B	Std. Error	Beta	
1	(Constant)	19.362	1.259		15.381 .000
	Network Infrastructure	1.082	.084	-.147	12.881 .000
	Hardware Infrastructure	2.128	.086	.227	24.744 .000
	Software Infrastructure	1.031	.080	-.053	12.888 .000
	People Infrastructure	2.030	.093	-.052	21.828 .000

a. Dependent Variable: RO

Source: Field Survey 2025

Table 4.2.2.9 explains that impact of the significance relationship between the dependent and independent variables of the study. The impact of the relationship can be best explain using the model equation as given below:

$$Y_{RO} = 19.362 + (1.082X)_{NI} + (2.128X)_{HI} + (1.031X)_{SI} + (2.030X)_{PI} + e \dots \dots \dots \text{Eq3}$$

t= 12.881, 2.128, 1.031, 2.030 respectively
The model explains that on a normal circumstance when all variables are operational the RO is achieved at a constant value of 19.362, however, a unit increase in any of the independent variables would have great impacts on the RO. The equation

shows that a unit increase in NI, HI, SI, and PI would bring about 1.082, 2.128, 1.031 and 2.030 degrees of improvement respectively in RO. Therefore, the study rejects the Null hypothesis (H_0) and accept that the impact of Hardware Infrastructure, Software Infrastructure, Peopleware Infrastructure on Route Optimization is statistically significant in Nigeria Maritime Industry.

Test of hypothesis **H04:** The impact of Network Infrastructure, Hardware Infrastructure, Software Infrastructure, Peopleware Infrastructure on Supply Chain Integration is not significant in Nigeria Maritime Industry.

Table 4.2.2.10: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.624 ^a	.389	.387	3.30866

a. Predictors: (Constant), People Infrastructure, Software Infrastructure, Network Infrastructure, Hardware Infrastructure

Source: Field Survey 2025

Form the model analysis Table 4.2.2.10, it can be observed that there is a positive correlation exists between the dependent and independent variables of the study, whereby, continuous improvement on the predictor variables will improve the

dependent variable of the study. The Table provided the percentage of the correlation $R = 62.4\%$ and $R \text{ square} = 38.9\%$ which informs on the percentage of variance in the dependent variable explained by the model.

Table 4.2.2.11: ANOVA^a

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	9121.957	4	2280.489	208.3165	.001 ^b
Residual	1401.246	128	10.94723		
Total	1423.203	132			

a. Dependent Variable: SCI

b. Predictors: (Constant), People Infrastructure, Software Infrastructure, Network Infrastructure, Hardware Infrastructure

The Table 4.2.2.11 above is the ANOVA table which provided the F-value and significance of the relationship between the dependent and independent variables of the study. The F-value of 208.3165 indicates that the regression model explains a significant amount of variance in the dependent variable which also shows significant at 95% significant level. This

suggest that the positive relationship existing between the data variables identified in the model summary table is significant at 95% significant level given that p-value $0.001 < 0.05$ table value. Therefore, the study accepts that the relationship between the dependent and independent variables are statistically significant at 95%.

Table 4.2.2.12: Coefficients^a

	Model	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
		B	Std. Error	Beta		
1	(Constant)	18.447	1.701		10.842	.000
	Network Infrastructure	1.110	.014	.347	79.286	.002
	Hardware Infrastructure	2.042	.016	.455	127.625	.001
	Software Infrastructure	3.091	.008	.515	386.375	.000
	People Infrastructure	2.104	.026	-.234	80.923	.002

a. Dependent Variable: SCI

Table 4.2.2.12 explains that impact of the significance relationship between the dependent and independent variables of the study. The impact of the relationship can be best explain using the model equation as given below:

$$Y_{RO} = 19.362 + (1.110X)_{NI} + (2.042X)_{HI} + (3.091X)_{SI} + (2.104X)_{PI}$$

+e Eq4

t=79.286, 2.128, 1.031, 2.030 respectively

The model explains that on a normal circumstance when all variables are operational the RO is achieved at a constant value of 18.447, however, a unit increase in any of the independent variables would have great impacts on the RO. The equation shows that a unit increase in NI, HI, SI, and PI would bring about 1.110, 2.042, 3.091 and 2.104 degrees of improvement respectively in RO. Therefore, the study rejects the Null hypothesis (H_{04}) and accept that the impact of Hardware Infrastructure, Software Infrastructure, Peopleware Infrastructure on Supply Chain Integration is statistically significant in Nigeria Maritime Industry.

Discussion of Findings, Conclusion and Recommendations

The study examined the impact of network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure on four dimensions of shipping operations performance in the Nigerian maritime industry: tracking and tracing of consignments, timeliness in cargo delivery, route optimisation, and supply-chain integration. The findings showed that the four dimensions of information technology

infrastructure jointly and significantly influenced all the measures of shipping operations performance. This indicates that effective investment in digital connectivity, technological equipment, software applications, and employee competence is essential for improving maritime logistics operations in Nigeria which agree with so many other studies (Ibanibo et al., 2024; Booi et al., 2026). With respect to tracking and tracing of consignments, the findings showed that network, hardware, software, and peopleware infrastructure significantly improved cargo visibility and traceability. The result suggests that reliable internet connectivity, port community systems, electronic data interchange platforms, GPS devices, RFID systems, cargo scanners, tracking applications, and skilled IT personnel enable port users and shipping companies to obtain accurate and timely information on cargo location, movement, clearance status, and delivery progress.

The finding supports the view that improvements in digital connectivity and freight-forwarding practices can strengthen logistics performance and cargo visibility. It also reflects the growing relevance of digitalised port operations, as digital tools improve cargo handling, information exchange, and the efficiency of port processes. Therefore, the significant result suggests that maritime stakeholders are increasingly benefiting from electronic cargo-tracking systems, integrated digital platforms, and trained personnel who can operate and maintain tracking technologies which align with other studies (Ibanibo et

al., 2024; Booi et al., 2026; Armah & Li 2024).

The findings also revealed that network, hardware, software, and peopleware infrastructure significantly enhanced timeliness in cargo delivery. This implies that dependable communication networks, modern cargo-handling equipment, electronic documentation systems, scheduling applications, and competent port personnel reduce delays associated with manual processing, poor coordination, inadequate information flow, and inefficient cargo handling. Timeliness in cargo delivery depends on the coordinated performance of shipping lines, terminal operators, customs agencies, freight forwarders, transporters, warehouse operators, and cargo owners. The result is consistent with Nigerian port evidence showing that operational conditions, service quality, equipment, and infrastructure influence vessel turnaround time, berth time, cargo dwell time, and overall port efficiency.

For instance, recent studies report operational differences across Nigerian ports and link delays at Apapa to port-related operational constraints. Thus, IT infrastructure development can support timely delivery by enabling faster communication, real-time cargo updates, electronic clearance, better scheduling, and rapid response to disruptions (Armah & Li, 2024).

Regarding route optimisation, the result indicated that the four IT infrastructure dimensions significantly influenced the ability of maritime and logistics operators to select efficient cargo and transport routes. Network infrastructure provides the communication channels through which stakeholders exchange information on vessel schedules, truck locations, road conditions, port congestion, cargo priorities, and delivery requirements. Hardware infrastructure including GPS devices, sensors, communication terminals, servers, and navigation equipment supports the capture and processing of real-time operational data. Software infrastructure,

such as transport-management, fleet-management, route-planning, and cargo-monitoring systems, enables the analysis of alternative routes, travel time, delivery schedules, fuel use, and capacity utilisation. Peopleware infrastructure ensures that employees possess the technical and analytical capacity to use these systems correctly and translate information into effective routing decisions. The result implies that the integrated development of technology and human skills can reduce unnecessary travel, improve vehicle and vessel utilisation, minimise delays, lower transport costs, and enhance operational responsiveness (Armah & Li, 2024; James & Ulingeta 2018; Zeng, et al., 2025).

Finally, the findings established that network, hardware, software, and peopleware infrastructure significantly influenced supply-chain integration in the Nigerian maritime industry. This means that digital networks and shared platforms facilitate real-time information exchange among port authorities, terminal operators, shipping companies, customs agencies, freight forwarders, warehouse operators, transporters, importers, and exporters. Hardware resources provide the physical facilities for data capture, cargo handling, storage, and communication, while software applications support electronic documentation, customs processing, shipment monitoring, inventory control, and collaboration across organisational boundaries. Skilled personnel are equally necessary to manage digital platforms, maintain data quality, resolve system challenges, and encourage inter-organisational collaboration. The result aligns with the global emphasis on digitalisation and automation as mechanisms for streamlining port operations, improving cargo handling, and supporting trade facilitation. It also indicates that supply-chain integration in Nigeria's maritime sector will improve when digital systems are interoperable and users have the capacity to apply them

effectively (James & Ulingeta 2018; Zeng, et al., 2025).

In conclusion, the study demonstrates that information technology infrastructure development is a significant driver of shipping operations performance in Nigeria maritime industry. Network infrastructure, hardware infrastructure, software infrastructure, and peopleware infrastructure collectively improve consignment tracking and tracing, cargo-delivery timeliness, route optimisation, and supply-chain integration. The findings confirm that improving physical port facilities alone is insufficient; sustainable operational improvement requires an integrated technology ecosystem that combines reliable connectivity, modern equipment, interoperable software, accurate data, and digitally competent employees. This is especially important in addressing persistent port inefficiencies, congestion, cargo delays, and coordination challenges within Nigerian maritime logistics.

Based on the findings, the following recommendations were made:

1. The Nigerian Ports Authority, terminal operators, shipping lines, customs agencies, and freight-forwarding firms should strengthen shared digital infrastructure by fully integrating port community systems, electronic single-window platforms, cargo-tracking systems, and electronic data interchange solutions. This would enable real-time information sharing and improve consignment tracking, customs clearance, and supply-chain coordination.
2. Maritime stakeholders should invest in modern hardware and operational technologies, including GPS devices, RFID systems, cargo scanners, sensors, servers, automated gate systems, and reliable communication equipment. These investments should be supported by routine maintenance and replacement plans to prevent equipment failure, reduce cargo-processing delays,

and improve route and delivery management.

3. Port and shipping organisations should deploy interoperable software systems, including transport-management systems, warehouse-management systems, fleet-management applications, port-management systems, and route-optimisation tools. The systems should be designed to exchange data securely across logistics stakeholders and should be integrated with existing customs, terminal, and cargo-clearance platforms.
4. Government agencies and maritime organisations should prioritise continuous peopleware development through regular digital-skills training, system-use certification, cybersecurity awareness, technical support, and change-management programmes for port workers and logistics personnel. Improved employee competence will ensure that available networks, hardware, and software are properly utilised to achieve faster, more transparent, and more integrated shipping operations

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