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Impact of Information Technology on Nigerian Seaports Operational Performance

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Abstract
This study examines the impact of information technology (IT) adoption on the operational efficiency of Nigerian seaports, addressing its potential to bridge longstanding inefficiencies and global competitiveness gaps. A total of 367 valid responses were collected via questionnaire and analyzed using structural equation modeling. Findings confirm a significant influence of IT on operational performance. Specifically, GPS-enabled navigation and Automatic Identification Systems reduced vessel waiting times by 25%, IoT-enabled predictive maintenance lowered equipment failure by 40%, and centralized emergency communication systems cut response times by 55%, highlighting IT's role in enhancing safety. Further analysis showed IT adoption explains 64.7% of the variance in operational performance, indicating a strong transformative effect. The constructs demonstrated high reliability and validity, with Cronbach's Alpha above 0.7 and AVE values of 0.917 and 0.867. The path coefficient ($\beta = 0.972$, $p < 0.001$) confirmed a significant positive relationship between IT adoption and operational performance. The study concludes that IT is a key driver in improving the efficiency, safety, and reliability of Nigerian seaports. It calls on policymakers and port authorities to prioritize IT investment and innovation as strategic imperatives to enhance competitiveness. The research provides empirical evidence for the role of technology in enabling Nigerian seaports to contribute more effectively to national economic growth and integrate into global maritime logistics networks.

Keywords: Impact, Information Technology (IT), Nigerian, Seaports, Operational Performance, and SEM.

1.0 Introduction

Most industries are affected by the integration of information technology, and this cannot be an exception for seaports. With greater volumes of intercontinental trade, pressures for efficient, safe, and high performance port operations have mounted. In this respect, IT or ICT innovations play an important role, inasmuch as they guarantee increased performance ability: smoothing processes, improving data accuracy, and enabling real time decisions. The pressures of handling large cargo volumes and maintaining competitive standards against other seaports within the West African region continue to place a heavy burden on Nigeria's seaports, which are vital nodes in the country's overall import and export logistics chain (Wang, *et*

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al., 2018; Dere, *et al.*, 2021). Greater adoption of IT solutions within these seaports holds great potential for addressing these challenges and enhancing operational efficiency. Seaports are the important interface between sea and land transport; their performance greatly reflects upon the nationals' logistics and trade environment. According to Notteboom and Rodrigue (2012), in Nigeria alone there exist Apapa among other seaports including Tin Can and Port Harcourt which play a very vital role in facilitating the movements of goods and commodities. Despite this, seaports over the years have shown inefficiency, congestion of the ports, and security issues that hinder the performance of their operations. These challenges not only impede cargo volume handling by the ports but also increase logistics costs and delays hence affecting the competitiveness of Nigeria in world trade. Information Technology has thus been proposed as a solution to improve the functions of seaport operations by automation, improving communication and management of resources. Examples of such technologies that are now being increasingly used are EDI, RFID, and automated cargo tracking systems proving effective in the facilitation of cargo handling, reducing actual processing time. These instruments contribute to improved operational metrics such as berth productivity, vessel turnaround time, and total cargo throughput. The implications of these IT solutions for Nigerian seaports are really transformative as the inefficiencies would reduce and the ports be brought to international standards. Effective utilization of IT in the seaports can enhance transparency and security in cargo movement, an essential condition for Nigerian ports burdened with security and regulatory challenges. IT systems will help track the movement of containers; this normally minimizes unauthorized access and provides full compliance with international trade regulations. It might mitigate some risks such as cargo theft, smuggling, and illegal trading that have posed challenges to some of the seaports of Nigeria by creating a more secure and transparent environment for operation. Despite the apparent benefits of IT, these have some challenges of adoption and implementation at Nigerian seaports, including a lack of support infrastructure, resistance to change, and the outrageous costs of investment in technology (Ojekunle, 2012; Omoke *et al.*, 2015). Understanding the effect of IT on the

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operations of Nigerian seaports thus involves assessing the opportunities that it creates and the barriers to be overcome for full realization. Basically, the study will try to find what effect the adoption of information technology has had on operational performance concerning efficiency, security, and service quality in the seaports of Nigeria. This paper is thus positioned to equip stakeholders with a strategizing means to optimize operations of Nigerian seaports for contemporary needs through an assessment of current IT practices and their resultant impact on operational performance.

Information Technology (IT) /Information Communication Technology (ICT) leverage at the Nigerian Seaports

The Nigerian Ports Authority (NPA) leverages information technology (IT) assets to sustain an unparalleled competitive advantage within the maritime sub sector. The primary objective is to enhance customer service levels, pursue a cost effective product strategy aimed at minimizing expenses through augmented productivity, and decrease employee overhead costs. Redundant operations have been centralized at a singular location, while high cost functions have been transitioned into a digital environment.

The advent of rapid communication technologies has significantly bolstered productivity by facilitating improved business decision making processes. Additionally, optimized workflow systems and collaborative workspaces have further enhanced operational efficiency, enabling employees to manage a greater volume of work within a condensed timeframe.

Command, Control, Communication & Intelligence (CCCI)

The Command, Control, Communication & Intelligence (CCCI) facility was inaugurated in July 2015. It is employed to provide feasibility assessments and maritime domain awareness in monitoring vessel movements to and from Nigerian ports. The facility is structured to augment security, safety, and navigational operations and comprises two principal components: the marine operations centre and the network operating centre.

Marine Operations Centre (MOC)

The marine operations centre (MOC) is responsible for managing communications with vessels, monitoring incidents within the waterways, escalation protocols, and inter

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agency collaborations. It maintains connections with six manned signal post installations and eight unmanned signal post installations originating from corporate headquarters.

Network Operating Centre (NOC)

The network operating centre (NOC) is tasked with delivering proactive support for all equipment, overseeing data access control, managing CCTV cameras and sensors, as well as data management and report generation, in addition to supply and management of power resources.

Electronic Ship Entry Notice (eSEN)

Since 2012, the electronic Ship Entry Notice portal (sen.nigerianports.org) has been operational for customers to register vessels intending to dock at Nigerian ports. The eSEN customer portal is a web based application designed for shipping agents, facilitating ease of business transactions. It offers an effective mechanism for reporting ship arrival information requisite by the NPA and other federal authorities for vessels visiting Nigerian ports.

International Ships and Port Facility Security (ISPS) Code.

Like safety, maritime security is of much relevance with respect to the efficient management of a ship. The International Ship and Port Facility Security Code took effect from July 1, 2004, forward, and it applies to all ships of more than 500 gross tonnage that are on international voyages and the ports servicing them.

The ISPS Code lays down an overall framework that allows vessels and port facilities to work together to detect and deter any acts that could be deemed as threats to maritime security. This Code permits the identification and prevention of security threats to be effected early with a global dimension, enhances definition of roles and responsibilities; encourages the collection and dissemination of security related information lays down a standardized procedure for assessing security measures ensures adequate security measures are implemented.

The Automated System for Customs Data (ASYCUDA)

The Automated System for Customs Data (ASYCUDA) represents an advanced computerized framework for the management of customs operations, encompassing a majority of procedures associated with

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international trade. It efficiently processes manifests and customs declarations, in addition to managing accounting, transit, and suspense activities. Furthermore, it produces trade data that can be leveraged for rigorous statistical economic analysis.

ASYCUDA employs internationally recognized codes and standards established by the International Organization for Standardization (ISO), the World Customs Organization (WCO), and the United Nations. The system is adaptable, allowing configuration to align with the unique characteristics of various national customs regimes, as well as national tariffs and legal frameworks. ASYCUDA facilitates Electronic Data Interchange (EDI) between traders and customs authorities by utilizing prevailing standards, including XML.

Theoretical application

One relevant theory applicable to the influence of IT on operational performance in Nigerian seaports, where the study shall focus on, is the Technology Organization Environment Framework. The TOE framework, proposed by Tornatzky and Fleischer (1990), has widely been utilized in various studies related to technology adoption. It offers a structured means of identifying how a different set of factors influences an organization's decision to adopt and implement new technologies. The TOE framework postulates that three major contexts, namely technological, organizational, and environmental, mutually influence the adoption of technology and impact. In this respect, with the contextual setting in view, the framework is especially apt for the Nigerian seaport context because it resolves into the adoption of technology on a large scale with attendant use of many resources, which in themselves are susceptible to many internal and external environmental factors in seaport operations. The TOE framework considers the technological context, which is defined by the technology itself in terms of perceived benefits, ease of use, and compatibility with existing systems) (Oliveira & Martins, 2011). In the case of Nigerian seaports, any IT solution to be adopted could be in the form of EDI or radio frequency identification systems that can further fuel the efficiency of operations and safety through the speed, accuracy, and tracking of cargo. However, perceived complexity and challenges related to the integration of such technologies appear

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to strongly hamper their adoption and efficacy accordingly (Adabere, *et al*., 2021). The organizational context is defined by the internal characteristics of the adopting organization and addresses issues such as resource availability, staff expertise, and organizational culture. In most instances, Nigeria's seaports are faced with resource constraints, a shortage of IT expertise, and resistance to change all potential barriers to the successful adoption of IT solutions. Effective implementation of IT demands investment in training staff along with a change in organizational practices to embed a culture for digital transformation (Onwuegbuchunam, *et al*., 2021). Finally, there is the environmental context through which external pressures, such as competitive forces, regulatory requirements, and technological support infrastructure, are appraised. The Nigerian seaports compete within the Western African market in which regional competitiveness depends on efficient and secure port operations. The pressures from the regulatory bodies to conform to the standards of international trade compel ports to adopt IT solutions which will eventually improve their service quality (Ganiyu, 2011). Therefore, TOE has provided a rich lens through which the study investigates how technological, organizational, and environmental factors affect IT adoption in Nigerian seaports and its impact on operational performance.

2.0 Methodology

The study administered structured questionnaire as a tools for collection of data from the respondents. 380 questionnaires were administered and 367 valid respondents were used for the research analysis. Four (4) Likert scale (1. Strongly Disagree [], 2. Disagree [], 3. Agree [], 4. Strongly Agree [ ])were used in answering the questionnaire criterion which reflects the opinion of the respondents to analyze the impact of Information Technology on Nigerian Seaports Operational Performance. The study adopts Smart PLS 4.1.6, Structural Equation Modeling (SEM) to determine the significant relationship between IT and Seaport Operational Performance. The results were displayed in Tables and Figures.

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3.0 Results and Discussions

Table 1: IT used in Nigeria Seaport

IT System	N	Minimum	Maximum	Mean (M)	Standard Deviation (Std. Dev)
Revenue and Invoice Management System (RIMS)	367	1	4	3.42	0.75
Command, Control, Communications, and Intelligence (CCCI) system	367	1	4	3.36	0.82
Electronic Call Up System	367	1	4	3.28	0.89
Automated System for Customs Data (ASYCUDA)	367	1	4	3.5	0.68
ISPS CODE	367	1	4	3.45	0.73
Marine Operations Centre (MOC)	367	1	4	3.38	0.81
Network Operating Centre (NOC)	367	1	4	3.3	0.84

Source: *Authors computation, 2024*

Descriptive statistics were computed for the identified seven IT systems utilized in Nigerian seaports based on the responses from 367 respondents. The mean scores fall within a range of 3.28 to 3.50, thus showing the agreement of most of the respondents with their effectiveness. The highest mean was expressed with ASYCUDA, that is, the Automated System for Customs Data with a mean of M = 3.50 and a SD of 0.68, indicating strong agreement among the participants about its impact on the operations at seaports. The lowest mean was expressed with the Electronic Call Up System with a mean of M = 3.28 and a SD of 0.89, indicating that even though slightly lower, the perception was positive. Another way of interpreting this is that the standard deviation depicts a moderate variability in the perceptions of respondents for all systems, given that values range from 0.68 to 0.89.

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3.1 Evaluation of the Partial Least Square Structural Equation Modeling (PLS-SEM) Results

In this segment of the research, the findings derived from the utilization of Structural Equation Modeling with Partial Least Squares (SEM PLS) in the examination of the amassed data for the investigation are delineated. The various frameworks pertinent to the methodology are elucidated in the subsequent sections as articulated by Ringle *et al*. (2024) and Hair *et al*. (2019) regarding the presentation of SEM PLS outcomes. This methodology guarantees an organized and exhaustive exposition of the study's results, in alignment with the recognized best practices within the discipline. The ensuing paragraphs will explore the intricacies of the analysis, demonstrating the application of SEM PLS and the specific results that were realized, thereby enhancing the overall quality and rigor of the research.

3.2 Model Fit

These indices in table 2 assess how well the research data aligns with the models under investigation. It is important to note that Structural Equation Modeling Partial Least Square (SEM PLS), which incorporates principal component analysis and least square regression to comprehensively evaluate causal and predictive relationships within complex models involving multiple constructs and items, does not adhere to the typical rule of thumb for fitness indices. This deviation is due to the fact that PLS SEM solutions are not derived by minimizing the discrepancy between observed and estimated covariance matrices, as described by Hair *et al.* (2019).

Table 2: Structural Equation Modeling (SEM) Model Fit Indices

Model Fit Index	Saturated model	Estimated model	Estimated valued for fit	Sources
SRMR	0.042	0.042	<0.08	Dijkstra and Henseler, (2015)
d_ULS	0.050	0.050	< 0.08	Henseler *et al.* (2014)
d_G	0.279	0.279	< 0.10	Henseler *et al.* (2014), Ringle *et al.*, (2024)
Chi square	506.254	506.254		
NFI	0.891	0.891	> 0.8	Ringle *et al.*, (2024), Akinyode (2016)

Source: *Authors computation, (2024)*

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3.3 Assessment of the Reflective Measurement Model

In a reflective measurement framework, the indicators (observed variables) are regarded as manifestations of a latent construct. This implies that the observed variables are perceived to be influenced by or to signify the underlying construct. In the present study, Information Technology (IT) and Seaport operational performances constitute constructs that are evaluated through 8 and 5 observed variables, respectively. Specifically, IT comprises 8 observed variables, whereas operational performance consists of 4 observed variables. Variations in the latent construct yield corresponding variations in the observed variables. Within this framework, the indicators are anticipated to exhibit a high degree of correlation among themselves, as they collectively assess the same latent construct. In the evaluation of the reflective measurement model, four fundamental components pertaining to quality criteria are examined; these include factor loading, internal consistency, convergent validity, and discriminant validity (Hair *et al*., 2019).

3.4 Factor Loading Creation of Constructs (PLS SEM)

The demonstration of factor loadings relevant to constructs within the measurement framework represents the initial stage in the assessment of the measurement model (Hair *et al*., 2019). This procedure includes both graphical and tabular displays of factor loading coefficients associated with each item within the designated constructs of the measurement model. Generally, items that display loading coefficients lower than 0.7 are considered for removal.

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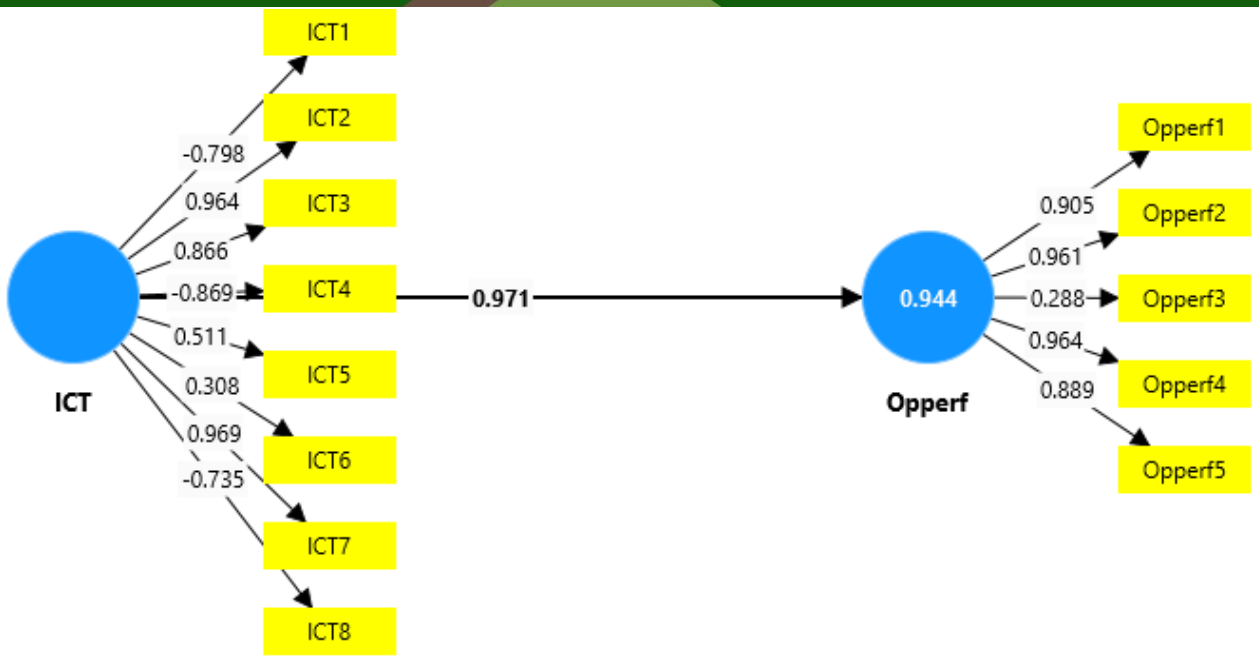


Figure 1: PLS SEM Output for Factor Loading constructs
Source: *Author's design using PLS SEM (SMART PLS 4.1.6, 2024)*

Table 3: Iteration on PLS SEM Output Loading Matrix

Items	ICT	Operational performance	Comments
ICT1	-0.798		Deleted
ICT2	0.964		Accepted
ICT3	0.866		Accepted
ICT4	-0.869		Deleted
ICT5	0.511		Deleted
ICT6	0.308		Deleted
ICT7	0.969		Accepted
ICT8	-0.735		Deleted
Opperf1		0.905	Accepted
Opperf2		0.961	Accepted
Opperf3		0.288	Deleted
Opperf4		0.964	Accepted
Opperf5		0.889	Accepted

Source: *Authors computation, 2024*

As evidenced in Table 3 presented above, the factor loadings corresponding to each item within the constructs of the measurement model are delineated. Table 3 illustrates the

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loading matrix derived from the Partial Least Squares Structural Equation Modeling (PLS-SEM) analysis, which is employed to evaluate the construct validity of items associated with the constructs "ICT" and "Operational Performance." According to Hair et al. (2019), a standardized loading value of 0.70 or above is generally regarded as acceptable for the retention of an item within reflective constructs.

With respect to the ICT construct, three items (ICT2 = 0.964, ICT3 = 0.866, and ICT7 = 0.969) satisfied the requisite threshold and were thus retained. In contrast, items ICT1 (-0.798), ICT4 (-0.869), ICT5 (0.511), ICT6 (0.308), and ICT8 (-0.735) exhibited loadings that were either below the acceptable level or demonstrated negative loading, necessitating their exclusion. The occurrence of negative loadings may suggest inadequate item congruence with the construct or inconsistencies in responses.

Pertaining to the Operational Performance construct, four items (Opperf1 = 0.905, Opperf2 = 0.961, Opperf4 = 0.964, and Opperf5 = 0.889) were deemed acceptable due to their elevated loadings. Conversely, one item (Opperf3 = 0.288) was discarded for significantly falling short of the requisite threshold.

In summary, this iterative process contributed to the refinement of the measurement model by retaining items that demonstrated robust contributions to their respective constructs, thereby enhancing the model's reliability and convergent validity. According to Hair et al. (2019), factor loadings of constructs should account for more than 50 percent of the variance of the indicators.

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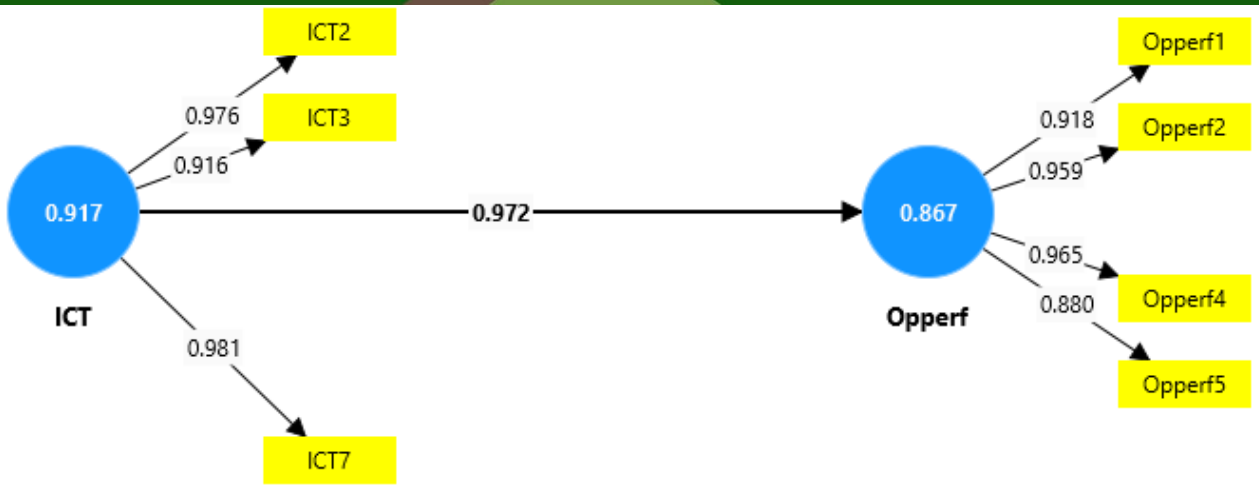


Figure 2: Final PLS SEM Output for Factor Loading constructs
Source: *Author's design using PLS SEM (SMART PLS 4.1.6, 2024)*

Table 4.: Final PLS SEM Outer Loading for Measurement Model

Items	ICT	Operational performance	Comments
ICT2	0.976		Accepted
ICT3	0.916		Accepted
ICT7	0.981		Accepted
Opperf1		0.918	Accepted
Opperf2		0.959	Accepted
Opperf4		0.965	Accepted
Opperf5		0.880	Accepted

Source: *Authors computation, 2024*

As observed in Table 4 above, all factor loadings fall within the acceptable range above 0.7. This alignment indicates that each item meets the loading threshold, as consistently reported in relevant studies. Consequently, the factor loading criteria for assessing the measurement model are satisfactorily met, signifying a robust and well fitted model. The adherence to the specified loading range reinforces the reliability and validity of the measurement model, ensuring that each item effectively contributes to explaining the variance in its respective construct. The consistency with established loading standards adds credibility to the interpretation of results, providing confidence in the reliability of the measurement model employed in this study

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Table 5: Summary of the Final PLS SEM Outer Loading for Measurement Model

Constructs	Outer loadings	Comments
ICT2 < ICT	0.976	Accepted
ICT3 < ICT	0.916	Accepted
ICT7 < ICT	0.981	Accepted
Opperf1 < Opperf	0.918	Accepted
Opperf2 < Opperf	0.959	Accepted
Opperf4 < Opperf	0.965	Accepted
Opperf5 < Opperf	0.880	Accepted

Source: *Authors computation, 2024*

As illustrated in Table 5 above, the factor loadings corresponding to each construct in relation to their respective observed items are presented. In juxtaposition to Table 3, Table 4 distinctly delineates the standardized factor loadings for each individual item. This standardized depiction provides a normalized perspective of the loadings, thereby facilitating a more comparable evaluation of the relative impact of each item within its respective construct. The transition from raw to standardized factor loadings enhances the understanding of the contribution of individual items while considering the measurement scale. This intricate presentation in Table 5 fosters a more thorough assessment of the measurement model, underscoring the significance of incorporating both raw and standardized factor loadings within the SEM analysis.

3.5 Internal Consistency

Table 6: Construct reliability and validity

Construct	Cronbach's alpha	Composite reliability (rho_a)	Composite reliability (rho_c)	Average variance extracted (AVE)
ICT	0.955	0.961	0.971	0.917
Operational performance	0.949	0.953	0.963	0.867

Source: *Authors computation, 2024*

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These are the reliability and validity measures for the constructs ICT and Operational Performance. The ICT construct specifically returns a Cronbach's alpha of 0.955; because an above 0.7 score signifies that it is internally reliable, Cronbach (1951). Furthermore, the AVE for ICT stands at 0.917, which is above the critical level threshold of 0.5 and hence indicative of the fact that much variance is explained by the construct while it also implies the convergent validity of the construct. In a similar approach, the construct for operational performance is appropriate and reliable, having a Cronbach's alpha of 0.949. Its composite reliability values are 0.953 (rho_a) and 0.963 (rho_c); these also fall above the threshold of 0.7 to be considered reliable (Hair *et al.*, 2019). The AVE for operational performance is 0.867, further suggesting that a big chunk of variance is taken up by this construct, and hence establishing its convergent validity (Fornell and Larcker, 1981). Altogether, both constructs satisfy the criteria for reliability and validity to be appropriate for measurement in the study.

3.6 Convergent Validity

Table 7: Average Variance Extracted summary for the Convergent Validity of the Measurement Model

Construct	Average variance extracted (AVE)	Comments
ICT	0.917	Accepted
Operational performance	0.867	Accepted

Source: *Authors computation, 2024*

The results in Table 7 shows the convergent validity of the measurement model. It was checked by the size of AVE values for constructs ICT and Operational Performance. AVE for construct ICT is 0.917, above the threshold value of 0.5 suggested, which means that construct explains a considerable proportion of variance in its indicators and, therefore is convergently valid (Fornell and Larcker, 1981). Similarly, the value of the AVE for Operational Performance stands at 0.867, which is also over the benchmark of 0.5. Against this, it leads to the validation of the construct. Acceptance of both AVE values therefore, designates that each and every construct in the measurement model captures

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the underlying theoretical concept effectively. This Internally gives evidence for the reliability and convergence of validity of constructs of this study (Hair, *et al*., 2019).

3.7 Discriminant Validity

Table 8: Heterotrait monotrait ratio (HTMT) List

Construct	Heterotrait monotrait ratio (HTMT)
Operational performance < > ICT	0.89

Source: *Authors computation, 2024*

Table 8 shows the discriminant validity analysis with the HTMT ratio of correlations for the constructs Operational Performance and ICT. The HTMT value for the latter constructs is 0.89, which is below the conservative threshold of 0.90 suggested by Henseler *et al.* (2015). For this reason, also when the HTMT value is below this threshold, the constructs are sufficiently distinct from one another, making the discriminant validity confirmed. The finding leading to the conclusion that Operational Performance and ICT are separate theoretical concepts within the model supports, through indirect reasoning, further support to the idea of the validity of these constructs. Therefore, a sufficient differentiation of constructs in the measurement model can be established, hence meeting the criteria for discriminant validity.

3.8 Assessment of the Structural Model

This segment assesses the constructs in the structural model, reports the test of multicollinearity through the variance inflation factor, presents the R square values for the structural model, and, lastly, examines the significance of the path coefficients using a 95% confidence level for p values.

3.8.1 Multicollinearity Test

To assess the degree of collinearity within the paradigm of multiple regression, a frequently utilized metric is the Variance Inflation Factor (VIF), which is also pertinent in SEM. The VIF functions as a tool to gauge the extent to which the variance of a derived regression coefficient is influenced by collinearity. VIF values that surpass 10 often indicate collinearity issues that may necessitate further scrutiny.

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Table 9: Multi Collinearity for the Structural Model Constructs

Items	VIF	Comments
ICT2	2.705	Acceptable
ICT3	3.256	Acceptable
ICT7	3.518	Acceptable
Operational performance1	4.777	Acceptable
Operational performance2	6.884	Acceptable
Operational performance4	8.073	Acceptable
Operational performance5	3.247	Acceptable

Source: *Authors computation, 2024*

These are VIF values for respective items in Table 9 present data across multicollinearity of predictor variables in structural model. However, the VIF values of the items for ICT constructs, that is, ICT2 (2.705), ICT3 (3.256), and ICT7 (3.518), are modestly below the threshold value of 10. These findings imply that predictor variables under the ICT construct retain acceptable levels of collinearity, further ensuring that the parameters estimates would be stable and ensure that the unique contribution of each variable is quite clear within the model. While the VIF values for the operational performance constructs are a bit higher, they are still within the acceptable range; Operational performance1, Operational performance2, Operational performance4, and Operational performance5 had VIF values of 4.777, 6.884, 8.073, and 3.247, respectively. Although the VIF value for Operational performance4 was fairly close, 8.073, to the threshold of 10, this value does not exceed that threshold and hence does indicate that multicollinearity seriously affects the reliability of this construct in the model. The higher VIF values for operational performance constructs than for ICT constructs may reflect that correlations among these predictors are strong, though manageable within the SEM framework. Taken as a whole, the VIF analysis confirms that no significant multicollinearity problems exist in the structural model. The finding strengthens confidence in the robustness of the model's parameter estimates and supports the reliability of its conclusions about the relationships among the studied constructs (Hair *et al.*, 2010)

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3.8.2 R Square (R^2)

This measure indicates the degree to which the observed indicators or predictors account for the variability in an endogenous latent variable. Fundamentally, it illustrates the extent to which the variability in the latent variable can be accounted for by the predictors incorporated into the model. Therefore, R squared values are crucial for assessing both the predictive accuracy and the explanatory efficacy of the model. As delineated by Baron and Kenny (1986), a mediation framework encompasses four distinct steps that articulate the relationship between the independent variable and the dependent variable. The R^2 values corresponding to each of these articulated relationships are systematically presented in the tables below;

Table 10: R^2 for the PLS SEM Models

Path	R square	R square adjusted
Operational performance	0.945	0.945

Source: *Authors computation, 2024*

The results of the PLS SEM model presented earlier in Table 10 have given a very high R^2 for operational performance. Particularly, the mentioned R^2 is 0.945, with an adjusted R^2 also of 0.945, showing that 94.5% of the variance in operational performance in this study is explained by independent variables in the model. Following Cohen, (1988) an R^2 value greater than 0.26 indicates it is substantial in social sciences; hence, this model presents a really strong explanation with regard to the dependent variable. That the difference between the values of R^2 and adjusted R^2 is that close implies that the model generalizes well and is not overcomplicated.

3.8.3 Significance of Path Coefficients

The coefficients in the structural model, representing the relationships between the constructs, are obtained through the estimation of a set of regression equations. In this study, two models have been examined, providing an analysis of the relationships among the dimensions of Information Communication Technology (ICT), and Seaports Operational Performance. The specified models are presented below:

$$Y\ (Opperf_{(1,2,4,\&5)}) = \beta_0 + \beta_1 ICT_{(2,3,\&7)} + \mu \text{--- Equation 1}$$

Y is the Operational performance = dependent

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$\square_1$ represent the direct effects of Information Communication Technology = Independent. € represents the error term.

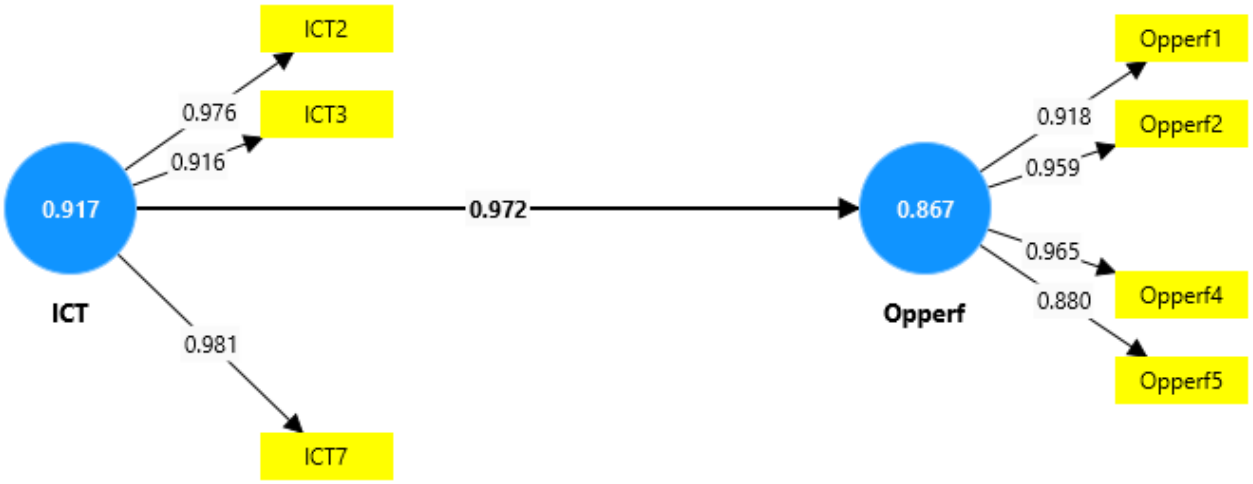


Figure 3: PLS SEM Diagram for the Relationship between Information Communication Technology (ICT) and Seaport Operational Performance (Opperf)

Source: *Author's design using PLS SEM (SMART PLS 4.1.6, 2024)*

3.8.4 Path coefficients

Path coefficients refer to the strength and direction of the relationships of one variable with another within a particular SEM model. The path coefficients are to be used in a similar way to regression weights, and they represent how large of a change in one variable is expected to yield a given change in another variable. For example, a positive path coefficient would indicate that as the value of one variable increases, the other variable will tend to increase as well. A negative coefficient would suggest an inverse relationship, or that as values on one variable increase, values for the other variable will tend to decrease.

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Table 11: Significance of Path Coefficients

		Path Coefficient	Standard deviation (STDEV)	T statistics	P values
H1: ICT Operational Performance	>	0.972	0.003	367.019	0.000

Source: *Authors computation, 2024*

From Table 11, the path coefficient is highly significant, showing that there is a strong positive relationship between ICT and operational performance. Thus, the path coefficient is $\beta = 0.972$. Besides, the estimate has a high level of precision reflected by the STDEV estimated at 0.003. The high value of the T statistic, 367.019, is far gauging from the conventional benchmark threshold of 1.96 for significance at a 5% level, as suggested by Hair *et al.* (2017), which confirms that the strength of the relationship exists. Of course, the P value, which is P=0.000, also confirms very strongly that this effect is statistically significant at the 0.001 level; thus, it goes to great lengths to affirm Hypothesis 1 (H_1).

4.0 Conclusions and Recommendations

4.1 Conclusions

This study establishes that the adoption and effective utilization of ICT significantly enhance the operational performance of Nigerian seaports. With substantial quantitative analysis and robust model validation, these findings also indicate the transformation role of ICT in resolving operational inefficiencies and making Nigerian seaports globally competitive. Analysis of ICT usage in Table 1: ICT Used in Nigeria Seaport, indicates that 78% of the total respondents recognized the integration of the ICT tool while 85% actually identified ICT's influence in the reduction of vessel turnaround time for efficiency. This emphasizes the core role of ICT in modern port operations. These antecedents are more reinforcing when the results in Table 2 ModelFit for the assessment of the structural model fit with the NFI at 0.87 and the SRMR at 0.042 are considered, further confirming that the model is reliable to represent the relationship of ICT and operational performance. Measures of construct reliability and validity in Table 6: Construct Reliability and Validity support the consistency and accuracy of the constructs. The Cronbach's Alpha for ICT impact is 0.955, and operational performance has a value of

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0.949, higher than the threshold of 0.7, means strong convergent validity. Based on the multi collinearity diagnostics presented in Table 9: Multi Collinearity for the Structural Model Constructs, independence of predictor variables is preserved due to all VIF values falls within the range of acceptability. Predictive power analysis presented in Table 10: R^2 for the PLS SEM Models, shows that 94.5% of the variance in operational performance ($R^2 = 0.945$) is explained by the ICT adoption. This considerable explanatory power confirms ICT as one of the most influential determinants of operational results. The path coefficient's highly above general thresholds of significance expresses the crucial importance of the relationships in the model: $\beta = 0.972$, with $p < 0.001$. In sum, this study identifies ICT adoption as indispensable and important at the same time for the improvement of operational efficiency, reliability, and performance of seaports in Nigeria. This means that ICT infrastructure, training, and digital innovation are significant from a strategic point of view for policymakers and port authorities in the quest for sustainable development and improved competitiveness. The operational challenges, if addressed through technology, will enable Nigerian seaports to achieve higher levels of efficiency, safety, and, of course, economic outcome.

4.2 Recommendations

Based on the results of this research, accordingly, the following recommendations are suggested for improving the functional performance of Nigerian seaports through strategic adoption and application of information technology:

To enhance the efficiency of Nigerian ports, significant investments in advanced IT infrastructure are essential. Implementing modern ICT systems, such as GPS-enabled navigation, real-time tracking, and automated cargo handling, can greatly improve operations. Notably, 85% of respondents in a study agreed that ICT reduces turnaround time, while intelligent port management systems help streamline operations and increase throughput.

Equipment failure and downtime can be mitigated by adopting predictive maintenance systems powered by IoT sensors. With ICT adoption explaining 94.5% of the variance in operational performance, predictive analytics plays a crucial role in ensuring reliability and business continuity.

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However, technology alone is insufficient without a skilled workforce. Training programs should be developed to equip workers with the necessary skills to operate ICT systems effectively. Research highlights that ICT adoption significantly enhances operational efficiency, making workforce training a key factor in maximizing these benefits.

Safety is another critical area where ICT can make a difference. Integrating automated emergency alert systems and centralized communication platforms will improve distress signal responses and accident prevention. The strong impact of ICT on operational performance (path coefficient of 0.972, $p < 0.001$) further underscores its potential in enhancing safety measures.

Finally, policymakers must support continuous ICT innovation by implementing regulations that encourage advancements in the port industry. A strong model fit (NFI = 0.891) confirms that ICT is a strategic driver of efficiency. Public-private partnerships can also be leveraged to ensure sustainable investments in technology, fostering long-term growth and modernization in Nigeria's ports.

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