The Influence of Port Characteristics on the Operational Performance of Sea Ports in Africa

Eng. Dr. Atonga, J. O

Doctor of Business Administration, Department of Business Studies, University of Nairobi, Kenya

DOI: https://doi.org/10.47772/IJRISS.2026.100500354

Received: 27 April 2026; Accepted: 02 May 2026; Published: 01 June 2026

ABSTRACT

This study aimed to determine the influence of organizational characteristics on the performance of seaports in Africa. The study replicates previous studies carried out in the European context by Caldeirinha et al. (2011) and Felicio et al. (2013; 2015). This study adopted a positivist research philosophy with a descriptive cross-sectional survey design. Structured questionnaires were used to collect primary data from executives at 54 container-handling seaport terminals in Africa. Of these, only 46 seaport terminals responded, with a response rate of 83.6%. The questionnaires conceptualized six port characteristics: location, size, infrastructure, information and communications technology, hinterland connectivity, and maritime connectivity. Model fitness was confirmed by the use of the Standardized Mean Root Square Residual (SRMR) and Normed Fit Index (NFI). Partial Least Squares Structural Equation Modeling (PLS-SEM) using Smart PLS 4.1.1 was used for both the measurement model and structural analyses. The findings established a positive and significant influence of port characteristics on the operational performance of seaports in Africa. The study also found that the strongest seaport characteristics for operational performance, in order of importance, are infrastructure, information and communications technology, strategic location, maritime services, hinterland connectivity, and size. The findings imply that for African seaports to improve their operational performance, they need to focus on developing port infrastructure, ICT, and an excellent strategic location.

Keywords. Partial least squares structural equation modeling, measurement model, port characteristics, operational performance, bootstrapping.

INTRODUCTION

Seaports act as interfaces between interlinking modes of transport, including maritime, rail, road, and inland waterways. According to the United Nations Conference on Trade and Development (UNCTAD, 2018), ports in developing countries account for 72 percent of the world's container trade, with Africa's share being only one percent. The main challenges facing African ports are inefficient operations, lengthy cargo clearing and dwell times, inadequate port and hinterland infrastructure, lengthy documentation processes, and low levels of automation. Utilization of technology by seaports for productivity has led to a 36 percent higher profit than competitors. The African Chief Executive Officers (CEOs) Forum (2021) endorsed measures that, if implemented, would improve the performance and competitiveness of African seaports. These included, among others, improvements in the public investment structure, the eradication of operational inefficiencies, and ambitious governance reforms to mobilize and attract public-private partnerships for financing (Port Strategy, 2021). The motivation behind this study was to address concerns about the inferior performance of most seaports in Africa compared with well-established seaports in the developed world, and to identify a solution to this persistent problem. The other motivation was to replicate, in the African context, findings from previous studies. The aim is to achieve high productivity and sustained performance (Notteboom, Pallis & Rodrigues 2022).

According to UNCTAD (2018), developing nations' ports handle 72 percent of the world's container trade, while Africa's share is only 1 percent. The main challenges that ports in Africa face are inadequate hinterland and port infrastructure, low levels of automation, unproductive cargo operations, long cargo clearing and dwell times, and lengthy documentation processes. The World Bank reports that ports in Africa handle over 90% of the continent's trade but suffer mainly from insufficient infrastructure. A 10% improvement in port operations can contribute to a 3% increase in trade volume, underscoring the direct impact of port efficiency on national GDP, a vital driver of economic growth (World Bank). According to Kamara et al. (2025), the African continent's maritime sector, which handles about 4% of global port throughput, is not adequately represented in global shipping dynamics due to challenges in infrastructure inadequacy, which has been a deterrent to the reduction of costs of shipping and integration of Africa more effectively into global supply chains. According to the World Bank, Ports that use technology to improve productivity have 36% higher profits than their rivals. Asian ports are mostly computerized, and the vessel turnaround period can be as little as 7 hours, compared with an average of 5 days for African seaports (Port Strategy, 2021). This study aims to identify solutions to improve the operational performance of African seaports.

LITERATURE REVIEW

Organizational characteristics are aspects of an organization that are associated with organizational performance. These characteristics are present in the organization's internal and natural environment resources. These characteristics include size, age, ownership, and diversification (Handoyo, Erlane, Ghani & Soedarsono, 2023; McMahon, 2012). Studies by Sunitiyoso et al. (2022); Caldeirinha et al. (2011), Felicio et al. (2013), and the World Bank (2007) identified determinants of port performance such as port size, infrastructure, age, strategic location, information and communications technology (ICT), efficiency level, costs, reliability, and the region's economic expansion. This study, however, adopted strategic location, size, information and communications technology, infrastructure, maritime services, and hinterland connectivity as the most important characteristics, especially applicable to seaports in Africa.

Strategic location refers to the closeness of a seaport to the main trade routes by sea, air, rail, and road, and proximity to the economic region that supports the port with highly efficient infrastructure. Organizations without the advantage of a strategic location can leverage efficiency and technology to enhance performance (UNCTAD, 2014). Efficiency and a good reputation are other important factors in performance (Notteboom & Rodrigues, 2022). The physical size of a port may well be used to define its real size, together with its combined labor and equipment. Studies have indicated that large-sized ports tend to give better performance than smaller ones (Handoyo et al., 2023). The port size, combined with operational efficiency and infrastructure, is crucial for determining the overall performance of a seaport. When the size of a port increases, it leads to substantial investments in infrastructure, such as deeper and wider shipping channels, more efficient cranes, and enhanced landside infrastructure (Notteboom, T., Pallis, A., & Rodrigue, J.P., 2026).

Infrastructure refers to the size and quality of an organization's internal capability. Studies have identified infrastructure as a contributor to performance (Rodrigue, 2020). In a seaport environment, infrastructure refers to the quality of physical structures, including berths, draughts, yards, quays, equipment, and road and rail infrastructure for cargo entry and evacuation (Rodrigues, 2017). Maritime services at a port encompass a wide range of activities vital to the port's smooth operation. These services include tug boats, piloting, mooring, bunkering, dry-docking, towing, salvage, vessel operation, and maintenance. Hinterland connectivity refers to how well a port is connected to nearby areas and beyond, with different transport modes such as road, rail, air, and water barge to move goods efficiently and promptly. Good connectivity is critical to the efficient movement of goods and services, enabling the port to serve inland markets effectively (UNCTAD, 2018). Adabere et al. 2021 aver that the integration of Information and Communication Technology (ICT) in seaport operations has considerably enhanced port performance and efficiency. Digital transformation entails a managerial and cultural shift that requires organizations to challenge their existing practices and integrate technology effectively. According to Notteboom et al. (2026), digital transformation demands a cultural and managerial paradigm shift that entails ports contesting their prevailing practices and effectively assimilating technology. Most previous studies were conducted in Europe and the Far East, not in Africa, hence the geographical and contextual gaps this study attempts to fill.

Organizational performance refers to the efficiency and effectiveness in the use of organizational resources and the attainment of its targets (Cera & Kusaku, 2020; Santos & Britos, 2012). Organizational performance involves the actual output of an organization compared to the anticipated outputs (Santos & Britos 2012). Port performance refers to the conduct of port activities in a way that satisfies the objectives and targets set by

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

shareholders and service providers, and meets the expectations of port customers. According to UNCTAD (2014), the performance of a port is a concept of multidimensional nature that encompasses the effectiveness of service, operational efficiency, and resilience to interruptions, measured through specific indicators to inform management decisions and boost the role of the port in trade globally. According to Richard et al. (2009), organizational performance encompasses three distinct zones of outcomes, including product market performance, which includes key performance indicators (KPIs) and metrics. In the context of seaports, Lam and Yap (2011) identified the performance measures as berth cargo throughput, operational efficiency, crane moves per hour, truck turnaround time, vessel turnaround time, terminal charges, and vessel and truck turnaround, which are crucial performance factors for terminal operators. This study adopted berth performance, yard performance, and cargo dwell time as key performance indicators for operational performance. From the literature review, a framework was conceptualized as shown in Figure 1.

CONCEPTUAL FRAMEWORK

The conceptual framework explained how the latent constructs of this study were related to one another. The independent latent variable was organizational characteristics, organized into dimensions such as strategic location, size, infrastructure, information and communications technology, maritime services, and hinterland connectivity. Operational performance measures included berth productivity, yard productivity, and cargo dwell time. The conceptual Framework is shown in Figure 1.

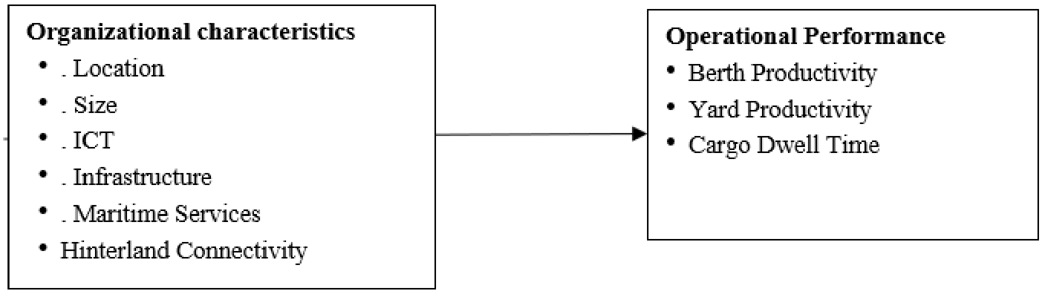

Figure 1. Conceptual Framework

Research Hypotheses

The hypotheses that were derived from the conceptual framework are stated as follows:

$H_{1:}$ There is no significant direct effect of organizational characteristics on the operational performance of ports in Africa.

$H_{ia.:}$ Port strategic location has no direct significant influence on the operational performance of ports in Africa.

$H_{b.}$ The size of a port has no direct significant contribution to the operational performance of ports in Africa.

$H_{c.:}$ Information and communications technology has no significant influence on port operational performance.

$H_{d.:}$ Port Infrastructure has no direct significant influence on the operational performance of ports in Africa.

$H_{e.}$ Maritime services have no direct significant influence on the operational performance of ports in Africa.

$H_{f.:}$ Hinterland connectivity has no direct significant influence on the operational performance of ports in Africa.

METHODOLOGY

A positivist philosophy was adopted when testing the resulting model. Similarly, a descriptive cross-sectional census survey research design was preferred to accommodate a low population of only 54 seaports in Africa. The chosen design was considered suitable for revealing the relationships between variables at a specific point in time (Saunders, Lewis, & Thornhill, 2007). Data was collected across targeted seaport terminals essentially at the same point in time. Data analysis was done using Partial Least Squares Structural Equation Modeling

(PLS-SEM) and regression analysis. Data were collected using structured questionnaires, which were sent by email to executives of the targeted seaports and also obtained from the websites of some of the seaports.

Diagnostic tests for normality, multicollinearity, autocorrelation, and heteroscedasticity were conducted on the study model to assess whether the collected data met the threshold for further analysis. In summary, all diagnostic tests indicated that the data collected for all variables met the threshold required for further analysis. At this juncture, Kaiser-Meyer-Olkin (KMO) and Bartlett's tests were carried out to determine the ability to carry out exploratory factor analysis (EFA) of all items of the latent constructs. The KMO tests revealed that all items were highly significant and equal to or above the threshold of 0.6 (Kaiser, 1974). Bartlett's Test showed that the chi-square values for all latent constructs were significant ($p = 0.001$; Bartlett, 1954). The KMO tests, therefore, certified all the items indicating the latent variables for exploratory factor analysis (EFA). Reliability tests were then conducted as detailed in the following sections.

Reliability Tests

The collected data underwent initial reliability tests using SPSS. The results for indicators of port characteristics are presented in Table 1, and those for operational performance in Table 2.

Table 1: Statistics on Organizational Characteristics

Indicator	Mean	SD	Factor loading	Item to total correlation	Alpha if item is deleted
Infrastructure	3.79	1.682	0.629	0.603	0.754
ICT	3.49	1.354	0.546	0.495	0.739
Hinterland connectivity	3.24	1.142	0.803	0.801	0.771
Size	3.12	0.889	0.750	0.823	0.805
Location	3.01	0.918	0.756	0.854	0.840
Maritime Services	2.92	0.860	0.564	0.660	0.815

The mean reflects the average scores by the respondents on their perceptions of the impact of individual port characteristics, ranked by importance from the questionnaire responses. The results indicate that port executives perceived infrastructure as the most important characteristic for port performance, followed by information and communications technology, hinterland connectivity, size, location, and maritime services.

Table 2: Statistics on Operational Performance

Indicators	Mean	SD	Factor loading	Item to total correlation	Alpha if item is deleted
Berth productivity	3.79	1.682	0.629	0.603	0.754
Yard productivity	3.49	1.354	0.546	0.495	0.739
Cargo dwell time	2.39	0.759	0.450	0.260	0.555

The mean represents the average score given by the respondents regarding their perception of the indicators' impact on port operational performance, based on their responses to the questionnaires. The responses indicate that port executives perceived berth productivity as the most important factor for operational performance, followed by yard productivity and cargo dwell time. Cargo dwell time was eliminated from further analysis because item-to-item correlation was less than the threshold of 0.3 (Hair et al., 2010).**3.2 Outer Model Loading**

To commence the analysis, an assessment of the indicators of each of the two latent constructs was conducted using the PLS-SEM model. A summary of the outcomes for the direct influence of organizational characteristics on the performance of African seaports is displayed in Table 3. The outcomes showed that indicator reliability for the two variables, organizational characteristics, and operational performance, was between 0.640 and 0.817, which is greater than the 0.4 specified by Hair (2010), and a good number is above the maximum level of 0.7

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

preferred by Vinz et al. (2010). The P values and all outer model loadings are significant, which permits further analysis (Wong, 2019).

Table 3: Results for Reflective Outer Models

	Indicator	Loadings	Indicator Reliability	T Statistics	P Value
Organizational Characteristics	Location	0.776	0.855	5.437	0.001
	Size	0.634	0.885	3.791	0.001
	ICT	0.753	0.835	1.998	0.001
	Infrastructure	0.817	0.836	5.176	0.001
	Maritime Services	0.812	0.837	5.658	0.001
	Hinterland connectivity	0.718	0.855	2.593	0.001
Operational Performance	Berth Productivity	0.781	0.769	5.832	0.001
	Yard Productivity	0.729	0.716	3.819	0.001
	Cargo Dwell Time	0.550	0.619	2.120	0.001

Before the structural model analysis, the two latent constructs and their indicators were tested for reliability and validity. The ensuing sections discuss analysis results for reflective variables as specified by Wong (2019).

Internal Consistency Reliability

Before subjecting the models to hypothesis testing, the measurement model was estimated using PLS-SEM to assess the internal consistency and reliability of the constructs and sub-constructs. Composite reliability values were used to assess internal consistency reliability. Table 4 presents the composite reliability scores for the latent variables.

Table 4: Construct Reliability and Validity of Latent Constructs and Indicators

	Composite Reliability	Cronbach's Alpha	AVE	P-Value
Organizational Characteristics	0.946	0.939	0.700	0.001
Operational performance	0.899	0.881	0/610	0.001
Location	0.811	0.745	0.792	0.001
Size	0.767	0.745	0.796	0.001
ICT	0.808	0.745	0.793	0.001
Infrastructure	0.814	0.809	0.893	0.001
Maritime Services	0.830	0.775	0.791	0.001
Hinterland connectivity	0.749	0.745	0.797	0.001

The results in Table 4 show that Cronbach's alpha values range from 0.745 to 0.939, while composite reliability values range from 0.749 to 0.946, indicating that internal consistency for the indicators was high. In both cases, the scores exceed the 0.7 threshold and are statistically significant, confirming the internal consistency of the sub-constructs (Hair Jr. et al., 2010).

Convergent Validity

Based on the findings in Table 4, the assessment of construct validity was conducted using both discriminant and convergent validity. Average variance extracted (AVE) scores were used to verify convergent validity for each construct. The results demonstrated that the latent variables AVE scores were 0.700 for organizational characteristics and 0.610 for operational performance. These values are all larger than the 0.5 threshold, thereby ascertaining convergent validity (Hair et al., 2010). The validity verification was also conducted using confirmatory factor analysis, as detailed in Table 5.

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Table 5: Confirmatory Factor Analysis Results

Indicator	Organizational Characteristics	Operational performance
Strategic Location	**0.814**	0.633
Size	**0.799**	0.546
Information Communications Technology	**0.894**	0.699
Infrastructure	**0.895**	0.591
Maritime Services	**0.863**	0.662
Hinterland Connectivity	**0.743**	0.516
Berth productivity	0.600	**0.798**
Yard productivity	0.288	**0.699**
Cargo dwell time	0.603	**0.840**

The results of confirmatory factor analysis in Table 5 revealed that the factor loadings of latent constructs articles had loaded highly onto the cross-loadings of corresponding constructs as further evidence of confirmation of convergent validity.

Discriminant Validity and Collinearity tests

The measurement aimed to authenticate that the two latent variables, organizational characteristics and operational performance, were as unrelated as possible. The validation was conducted using the Fornell-Larcker and Heterotrait-Monotrait (HTMT) criteria. Both tests confirmed that the two latent variables were not related; hence, discriminant validity was established. In this model, only the outer model collinearity assessment was conducted, as there was only one independent variable. The results indicated that the outer model's latent constructs had VIF values below 5. Similarly, the tolerances were greater than 0.2, which supports the outer model's lack of multicollinearity.

Hypotheses Testing and Results

The hypotheses were tested by using PLS-SEM analysis. Hypothesis 1 was tested first to determine the effect of organizational characteristics on operational performance. This was followed by testing Hypotheses Ha to Hf to determine the effect of each port characteristic, thus, strategic location, size, information communications technology, maritime services, and hinterland connectivity on operational performance of seaports in Africa.

Hypothesis H1

The null hypothesis, H1, stated that “There is no significant direct effect of organizational characteristics on the operational performance of ports in Africa.” This hypothesis was tested using PLS-SEM analysis. The test results are shown in Figure 1. Cargo dwell time EOPiii was eliminated from analysis because item-to-iem correlation was below the threshold of 0.3 (Table 2).

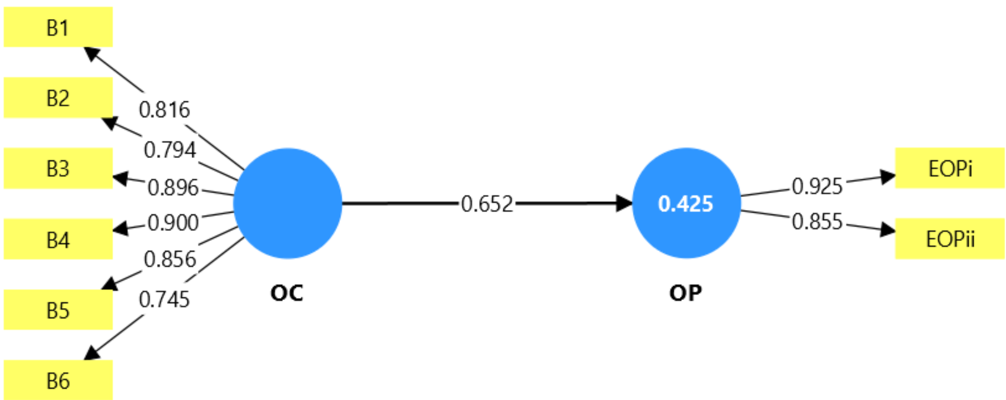

Figure 1: Diagram of Model with R2, Path Coefficients, and Loadings

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From Figure 1, PLS-SEM analysis results (β = 0.652, R2 = 0.425, p = 0.001) indicate that the factor loadings for port characterizing factors range from 0.745 for hinterland (B6) to 0.900 for infrastructure (B4), which had the highest factor loading (0.900). For operational performance indicators, the factor loadings range from 0.855 for yard productivity (EOPii) to 0.925 for berth productivity (EOPi). All factor loadings exceeded the minimum threshold of 0.4 specified by Hair et al. (2010). The explained variance, R2, attributed to organizational characteristics is 0.425. This implies that port characteristics explained only 42.5% of the variance in operational performance. The path coefficient between port characteristics and operational performance is 0.652. This implies that 65.2% of the variance in port characteristics is responsible for the change in variance in organizational performance.

Data Analysis and Findings

To investigate the remaining hypotheses, PLS-SEM analysis was carried out to determine the effect of each port characteristic, namely Location, Size, ICT, Infrastructure, Maritime Services, and Hinterland Connectivity, on the operational performance of ports in Africa.

Hypothesis Ha

The null hypothesis states that “Port Strategic Location has no direct significant influence on the operational performance of ports in Africa”. In the ensuing PLS-SEM analysis, Strategic Location was the independent variable while Operational Performance was the dependent variable. Figure 2 elucidates the results of the analysis.

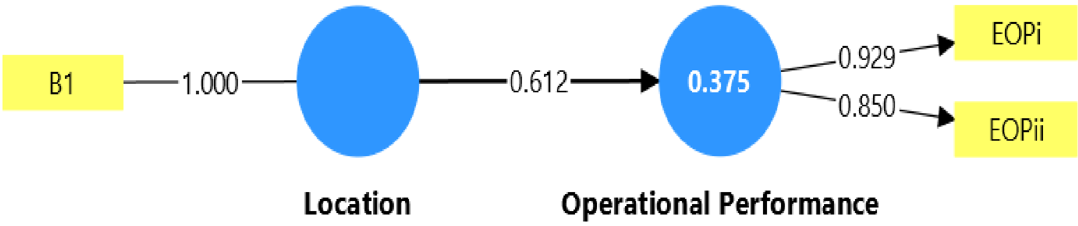

Figure 2: Model Diagram showing the Effect of Location on Operational Performance

From the results in Figure 2 (β = 0.612, R^2 = 0.375, p = 0.001), the inner model suggests that the path correlation (β) between strategic location and operational performance is 0.612. The explained variance, R^2, value for this model is 0.375. It is also confirmed that all indicator factor loadings were above the minimum threshold of 0.7. The result implies that strategic location explains 37.5% of the variance in operational performance. Bootstrapping results from 5000 resamples revealed a p-value of 0.001. The relationship between the exogenous and endogenous variables is therefore statistically significant since p is less than the maximum threshold of 0.05. The null hypothesis is therefore rejected. The analysis found that strategic location has a direct and significant effect on the operational performance of ports in Africa.

Hypothesis “H_b:

The hypothesis stated: “The size of a port has no direct significant effect on its operational performance.” In the ensuing PLS-SEM analysis, Size was the predictor of operational performance. Figure 3 displays the analysis results.

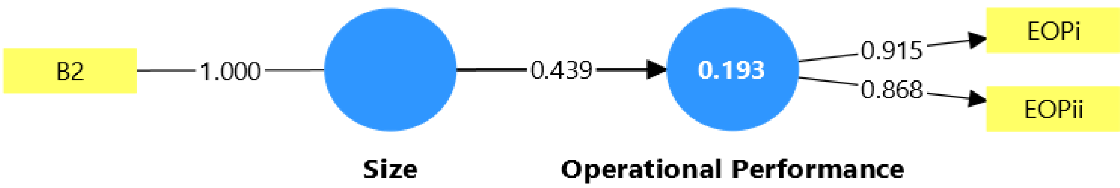

Figure 3: Model Diagram showing the Effect of Port Size on Operational Performance

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The PLS-SEM analysis results in Figure 3 (β = 0.439, R^2 = 0.193, p = 0.001) indicate that, in the inner model, the path coefficient between port size and operational performance is 0.439. It is also confirmed that all indicator factor loadings were above the minimum threshold of 0.7. The change in variance, R^2, for this model is 0.193, indicating that port size explains only 19.3% of the variation in operational performance. Bootstrapping results from 5,000 resamples yielded a p-value of 0.001, below the maximum threshold of 0.005. The relationship between the exogenous and endogenous variables is therefore statistically significant since p is less than 0.05. The null hypothesis is therefore rejected. The analysis found that port size has a significant effect on the operational performance of ports in Africa.

Hypothesis H_c

The hypothesis stated, "Information and communications technology (ICT) has no significant influence on port operational performance. The hypothesis was tested using PLS-SEM analysis, with the results shown in Figure 4.

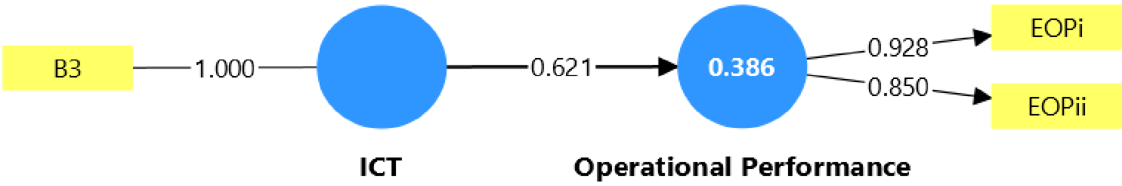

Figure 4: Model Diagram showing the Effect of ICT on Operational Performance

The structural model results in Figure 4 (β = 0.621, R^2 = 0.386, p = 0.001) indicate that the inner model path coefficient between ICT and operational performance is 0.621. All the indicator factor loadings are above the minimum threshold of 0.7. The explained variance, (R^2), for this model is 0.386, indicating that ICT explains only 38.6% of the variance in operational performance. Bootstrapping results with 5000 resamples revealed a p-value of 0.001, which is less than 0.005. The relationship between ICT and operational performance is therefore statistically significant since p is less than 0.05. The null hypothesis is therefore rejected. The analysis finds that ICT has a direct, significant effect on the operational performance of ports in Africa.

Hypothesis H_d

The hypothesis stated, "Port infrastructure has no significant influence on port operational performance of ports in Africa. In the ensuing PLS-SEM analysis, Infrastructure was the independent variable and therefore the predictor of operational performance, the dependent variable. Figure 5 displays the structural model results.

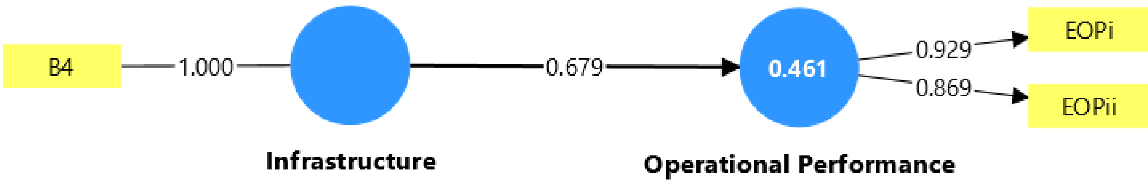

Figure 5: Model Diagram showing the Effect of Port Infrastructure on Operational Performance

The results of the structural model analysis in Figure 5 (β = 0.679, R^2 = 0.461, p = 0.001) indicate that the inner model path coefficient between port infrastructure and operational performance is 0.679. The factor loadings ranged from 0.969 to 1.0; therefore, all were above the minimum threshold of 0.7. The explained variance, R^2, for this model is 0.461, which implies that port infrastructure accounts for 46.1% of the variance in operational performance. Bootstrapping results from 5000 resamples yielded a p-value of 0.001, below the maximum

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threshold of 0.005. The relationship between the exogenous and endogenous variables is therefore statistically significant since p is less than 0.05. The null hypothesis is therefore rejected. The analysis found that port infrastructure has a direct, significant influence on the operational performance of ports in Africa, and emerged the strongest factor.

Hypothesis H_e

The hypothesis stated: "Maritime Services of a port has no direct significant influence on operational performance of ports in Africa." The hypothesis was tested using PLS-SEM, with the findings shown in Figure 6.

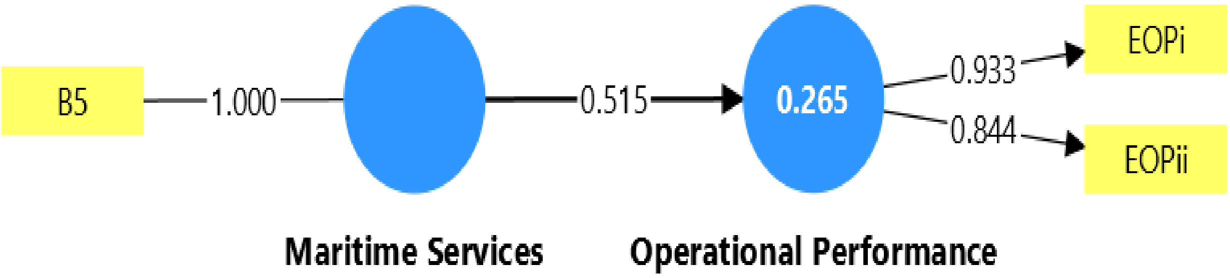

Figure 6: Model Diagram showing the Effect of Maritime Services on Operational Performance

The results of the structural model analysis in Figure 6 ($\beta = 0.515$, R2 = 0.265, $p = 0.001$) indicate that the path coefficient between maritime services and operational performance is 0.515. All the indicator factor loadings are above the minimum threshold of 0.7. The explained variance (R^2) for this model is 0.265, indicating that maritime services explain only 26.5% of the variance in operational performance. A bootstrapping test with 5000 resamples showed a p-value of 0.001, which is less than 0.005. The relationship between maritime services and operational performance is statistically significant since p is less than 0.05. The null hypothesis is therefore rejected. The analysis finds that maritime services have a direct, significant effect on the operational performance of ports in Africa.

Hypothesis H_f

The Hypothesis stated that: Hinterland connectivity has no significant effect on the operational performance of ports in Africa. The analysis was conducted using PLS-SEM, as detailed in Figure 7.

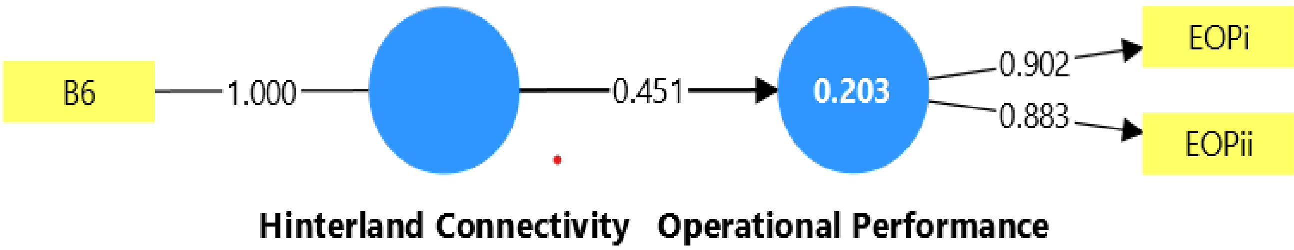

Figure 7: Model Diagram showing Hinterland Connectivity on Operational Performance

Figure 7 results ($\beta = 0.451$, $R^2 = 0.203$, $p = 0.001$) indicate that, in the inner model, the path coefficient between hinterland connectivity and operational performance is 0.451. All factor loadings ranged from 0.883 to 1.0 and were therefore above the minimum threshold of 0.7. The change in variance, R^2 for this model is 0.203, which implies that hinterland connectivity explains only 20.3% of the variance in operational performance. A bootstrap test with 5000 resamples yielded a p-value of 0.001, which is below the maximum threshold of 0.005. The relationship between hinterland connectivity and operational performance is therefore statistically significant since p is less than 0.05. The null hypothesis is therefore rejected. The analysis, therefore, concluded that hinterland connectivity has a direct and significant effect on the operational performance of ports in Africa.

SUMMARY OF FINDINGS, CONCLUSIONS, AND RECOMMENDATIONS

The main purpose of the investigation was, first, to establish the effect of the linkage between organizational characteristics on the operational performance of seaports in Africa. The second purpose was to establish the individual effects of strategic location, size, information and communication technology, infrastructure, maritime services, and hinterland connectivity on the operational performance of seaports in Africa. Analysis was conducted to examine the relationships between the port characteristics and operational performance of ports in Africa. A second set of analyses was carried out to determine the relationships between individual sub-variables and operational performance. The research findings are presented in the following subsections.

Port Characteristics and Operational Performance

This study found a positive and statistically significant relationship between port characteristics and the operational performance of ports in Africa. These results imply that port and terminal characteristics directly contribute to the operational performance of ports in Africa. The findings align with previous research by Caldeirinha et al. (2011) and Felicio et al. (2013, 2015), who also found that port characteristics significantly contribute to port and terminal performance in Europe. Ports in Africa will have to identify and optimize the use of their characteristics to achieve higher performance.

Strategic Location

The analysis showed that the postulated path relationship between strategic location and operational performance was positive and statistically significant. The implication is that strategic location has a positive and significant effect on the operational performance of African seaports. Previous scholars, including Caldeirinha et al. (2011), Felicio et al. (2015), and Mou et al. (2021), found that strategic location was the most important factor for port and terminal performance in Europe. However, Notteboom and Wang (2015) and Murphy (1991) found that strategic location has become less important due to the use of ICT in operations and supply chain networks. This research places strategic location as the third most important factor for the operational performance of African seaports.

Size

The research outcomes indicated a statistically significant but relatively weak relationship between port size in Africa and operational performance. The results imply that the size of an African seaport is not a significant contributor to its operational performance. Previous studies by Sohn and Jung (2009) reveal that larger Asian ports exhibit better cargo-handling efficiency than others and hold a larger market share in container transshipment. However, they also observed that the size effect of a port remains an insignificant factor until annual container throughput reaches 5 million twenty-foot equivalent units (TEU). Tongzon and Heng (2005) and Pirez da Cruz et al. (2013) argue that smaller ports were more competitive and performed better than larger ports due to improved efficiency.

Information and Communications Technology (ICT)

The research analysis results showed a positive and significant correlation between the use of information and communications technology in African ports and their operational performance. The findings reveal that ICT is a highly significant predictor of operational performance in African seaports, with a beta coefficient of 0.621, an explained variance of 0.386, and a significance level below the 0.05 threshold. The results agree with Adabere et al. (2021) that the incorporation of ICT in operations of seaports has considerably enhanced performance and efficiency, and that management of ports must continue to invest in emerging technologies and also encourage employees by way of developing strong capabilities of the staff and their adaptability to IT, and the willingness of port users to accept change. Notteboom et al. (2026) agree that digital transformation of seaports encompasses the integration of ICT into business processes; the improvement of performance and the addition of value for customers through digitization; the transformation of documents and digitalization; and the transformation of operations and business processes through various forms of automation.

ISSN No. 2454-6186 | DOI: 10.47772/IJRISS | Volume X Issue V May 2026

Infrastructure

Empirical validation outcomes for the hypothesis confirmed that infrastructure has a positive and statistically significant correlation with the operational performance of ports in Africa. The analysis revealed that infrastructure was the strongest factor for the operational performance of ports in Africa. These findings align with the views of Adabere et al, (2024) and Liu (1995), who argue that port infrastructure plays a key role in the operational efficiency and competitiveness of ports and cargo terminals. They aver that infrastructure modernization is vital to meeting the challenges posed by increased demand and larger vessel sizes, including capacity expansion, investments in modern equipment, and the adoption of advanced technologies. These findings are echoed by Mlambo (2021), who states that the performance of African seaports and their impact on trade demand the development of infrastructure to sustain economic growth, improve port efficiency, and enhance port competitiveness. The findings are also echoed by Kamara et al. (2025) that infrastructure investments at Queen Elizabeth II Quay, Sierra Leone, improved operational performance, and led to 30% increase in cargo throughput and a 25% reduction in vessel turnaround times, a reduction of congestion, and a contribution to economic growth by attracting international trade. The findings also confirm the effect of large-scale infrastructure development at Tangier Med Port, Morocco, which enabled the port to handle over 11 million TEUs in 2025, up from 4.8 million in 2021, an increase of 131% in five years, or 25.8% annually, thereby becoming the leading port in Africa and the Mediterranean region (Elkhouly, 2026). The World Bank's Container Port Performance Index 2025 ranks Tangier Port as the world's fifth-most-efficient port. Egypt’s Port Said ranks as the second-best-performing port in Africa due to heavy investment in infrastructure upgrades.

Maritime Services

The results of the PLS-SEM analysis established that maritime services are positively and significantly associated with the operational performance of African seaports. The study findings concur with Mlambo (2021), who aver that efficient maritime services improve seaport performance and are vital for reducing trade costs, connecting supply chains, and promoting global trade. According to UNCTAD, efficient maritime services lead to cost reductions, fewer delays, improved goods movement, increased throughput, greater efficiency, and faster vessel turnaround, and are therefore an important factor in port performance. Efficient and effective maritime services are the backbone of a port's competitiveness, directly impacting everything from local job markets to global supply chain reliability. These sentiments are echoed by the World Bank, which states that efficient and effective maritime services reduce logistical costs, accelerate vessel turnaround, and enhance global competitiveness and supply chain resilience, among other benefits.

Hinterland Connectivity

The findings of this research indicate a positive and statistically significant relationship between hinterland connectivity and operational performance of ports in Africa. The results align with the findings of UNCTAD 2021 and Notteboom et al. (2026) that hinterland connectivity significantly impacts seaport performance, including good transport links to and from ports, connections to neighboring landlocked countries, and optimized trade facilitation measures. According to Merk and Notteboom (2015), the aim is to integrate the port system into a multimodal transportation network to improve access to markets, trade fluidity, and integration with industrial networks. The importance of hinterland connections has been recognized as one of the most critical issues for port competitiveness and development in ports worldwide (OECD).

SUMMARY OF FINDINGS

The main aim of this study was to determine the relationship between port characteristics and operational performance of ports in Africa. The second aim was to determine the individual effect of location, size, ICT, infrastructure, maritime services, and hinterland connectivity on the operational performance of ports in Africa. This study established that the strongest and most important contributor to performance for African ports is Infrastructure. Africa, as a developing continent, has many factors contributing to poor port performance, including underdeveloped infrastructure in ports and the hinterland. As a result of reforms in governance structures, most African ports are adopting the landlord model of governance, in which, although the ports or terminals remain publicly owned, the private sector invests heavily in infrastructure and superstructure development to improve port performance. A clear case is the reforms to the governance of the Tangier Med port in Morocco, where, under a landlord model, the redevelopment of infrastructure and ICT in a strategic location turned it into the best-performing port in Africa and the Mediterranean, and the fourth most efficient port terminal in the world.

This research revealed that the use of information and communication technology, through digitization and digitalization, is the second-most important factor in improving the operational performance of African seaports. Use of ICT, especially through the automation of port operational services, together with modern and adequate infrastructure, has improved efficiency in port operations, reduced port service costs, and reduced cargo dwell time.

Strategic location was identified in this research as the third most important factor for improving the operational performance of African ports. Whereas previous studies conducted in Europe and the Far East found that the most important factor for port operational performance was strategic location, this study ranked it as the third most important factor for improving operational performance, after infrastructure and ICT. This is probably premised on the fact that, unlike African ports, which still need to develop their infrastructure, European and Far East ports have fully developed infrastructure for port operations, with the main differentiating factors being the importance of the port's location and the governance model adopted by the port.

Maritime services were established by this research as the fourth most important characteristic of operational performance for African ports. Highly efficient and effective maritime services lead to faster vessel turnaround, which in turn results in faster integration of supply chain networks, reduced costs of doing business, and the promotion of international trade. Although a very important factor in port operational performance, African seaports currently rate it after infrastructure, ICT, and strategic location.

The research found that hinterland connectivity was the fifth most important factor for operational performance among African ports. Efficient integration of land transport systems in the hinterland enhances logistics performance, reduces vessel turnaround time, and improves overall port performance. This is particularly evident in ports such as Mombasa, Durban, and Lagos, where the integration of land transport systems has been shown to significantly impact port performance.

The research found that port size was the least important factor for the operational performance of ports in Africa. Sohn and Jung (2009) aver that seaport size influences performance, but not in a straightforward manner. This is because the increased size also requires substantial investments in infrastructure, such as deeper and wider shipping channels, more efficient cranes, and enhanced landside infrastructure. Therefore, determining the overall operational performance of a seaport requires a combination of port size, infrastructure, and operational efficiency.

CONCLUSION

The research established that infrastructure development is the leading driver of improved port operational performance in Africa. Operational success can only be achieved if infrastructure development is intertwined with modern ICT development, particularly digitization, which encompasses transforming documents, contracts, etc., into digital format, and digitalization, which involves transforming business processes and operations through various forms of automation. The success of combining infrastructure and ICT development is ensured when the port or terminal is situated in a strategic location, such as Tangier Med Port in Morocco. The three factors, infrastructure development, ICT, and strategic location, must go hand in hand for the achievement of the most competitive and best-performing port in Africa.

Having said that, the importance of the port's maritime services for faster vessel turnaround cannot be gainsaid, as this is a major factor in overall port efficiency and competitiveness. The success of the first three factors for improved operational services will depend on efficient and effective maritime services. As for hinterland connectivity, while it may not be a major factor for pure transshipment hubs like Tangier, it is a critical factor for gateway ports like Mombasa, Durban, Dar es Salaam, Lagos, Tema, to name but a few. An efficient hinterland transport corridor with effective intermodalism and adequate security and safety for goods and services will ensure faster turnaround of containers at the gateway port, which in turn would enable faster evacuation of containers and goods for export. This research did not adequately appreciate the importance of port size in improving operational performance in African ports. This could be an area for further research.

Implication of this Study

The results of this study have implications for knowledge, managerial practice, and policy.

Implications on Knowledge

The study contributes to new knowledge and addresses the shortcomings of previous studies by contextualizing seaport characteristics in Africa rather than in Europe and the Far East, thereby resolving the geographical and contextual gap. Another new finding is that the study identifies infrastructure as the leading factor, supported by advances in ICT and effective maritime services in strategic locations, which drive the operational performance of ports in Africa.

Implication on Managerial Practice and Policy

Practitioners such as seaport managers, shareholders, government, and regulators will benefit from new knowledge on improving seaport performance through the identification and improvement of natural port characteristics, key among them port and hinterland infrastructure, ICT, strategic location, and maritime services, and ICT as drivers of operational performance for seaports in Africa. By singling out infrastructure supported by ICT as key drivers of operational performance, the practitioners and port managers may resort to carrying out reforms in governance, for example, to adopt the landlord model, in order to inject private sector investment in port development, to improve infrastructure and ICT. The economic benefits to be derived from the investment include direct and indirect businesses and employment in the industry by private investors.

Policymakers will be well guided by information and knowledge as they plan the modernization of existing seaports or the development of new ports at greenfield sites. The results would provide valuable guidance for improving the performance of seaports in Africa. This, in turn, could increase the share of containers handled by seaports in Africa from the present one percent to a higher figure for developing countries.

RECOMMENDATION

This research identifies infrastructure development, with ICT support, as the leading factor in the operational performance of ports in Africa. Since infrastructure and ICT development are costly and resources in public service ports are scarce. African ports must reform to the landlord model of port governance to raise adequate capital for port infrastructure development through private-sector financing. This is the only way that African ports will improve and sustain their operational performance to world-class standards.

Limitations of the Study

The targeted respondents were port executives whose views could be biased. Possible respondents, like port stakeholders, shipping lines, suppliers, transporters, community leaders, freight forwarders, government agencies, regulators, and share-holders were excluded in the study, so were financial, efficiency, and economic indicators.

Recommendation for Future Research

Should African ports adopt the landlord model in the reforms, develop modern infrastructure and ICT, this study should be replicated in 5-10 years to determine the factors that will then be drivers of their operational performance. The relevance and contribution of port size to operational performance should also be highlighted in future studies, as this factor did not emerge as significant in this study. Future research should include all port stakeholders, financial, economic, and market share indicators in order to improve model fit indices and generalizability.

Declarations

Funding:

No funding was received for this research.

Conflict of Interest:

Author declares no conflict of interest

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