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Port Capacity, Vessel Turnaround Time and Merchandise Trade in Selected African Countries: Evidence from Panel Data

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Abstract

This study investigated port capacity, vessel turnaround time and merchandise trade in selected African countries: Evidence from panel data. The objectives of the study were to evaluate the effect of port vessel capacity of deep seaports on the merchandise trade volume; assess the effect of vessel turnaround time of deep seaports on the merchandise trade volume, and establish the joint effect of the port vessel capacity and vessel turnaround time of deep seaports on the merchandise trade volume of selected African countries. Panel-data study research design was adopted. Secondary data from statistical bulletins in Nigeria, Ghana, Kenya, Tanzania, Morocco, South Africa and United Nations Conference on Trade and Development from 2000 - 2026 were collected. The data were analysed using Pooled panel regression method after establishing the results through Hausmann specification testing. The findings revealed that port vessel capacity and vessel turnaround time each have statistically significant effect on merchandise trade volume of the selected African countries; and port vessel capacity and vessel turnaround times have a statistically significant joint effect on merchandise trade volume of the selected African countries. The study concluded that deep-seaport expansion can facilitate the economic growth of African countries. It was recommended, among others, that African countries government should accelerate deep seaports infrastructural development through increased capital investments and automation of port clearance systems in African ports. This study underscores the critical need to adapt contemporary Management and Business Education curricula to meet the practical realities of African maritime trade and regional port operations.

Keywords: Deep-water Ports, Trade Facilitation, Panel Econometrics, Port Efficiency, Management, Business Education.

Introduction

The deep seaports in African countries stand at the intersection of national development strategy and the forces of globalization; serving as conduits for commerce, energy, and regional integration. They represent some of the most consequential infrastructure assets on the continent. It is captured that approximately 90 percent of Africa's total trade is conducted via the sea, rendering maritime infrastructure not merely logistical but existential for African economies (Quedraogo, 2025). However, over the years, the global economic landscape has faced rapid spatial configurations and reconfigurations, driven by expanding international merchandise trade volumes and the integration of mainly raw materials producing nations into the global value chains (GVCs). Available recent data have shown that seaborne transportation accounts for more than four-fifths of total international trade volume by weight (United Nations Conference on Trade and Development (UNCTAD, 2024; 2025). This makes maritime infrastructure, a primary engine of economic globalisation.

Historically, African coastal countries' trend of merchandise trade volume has been characterised by not-too-aligning structure, as it is marked with high volume, the exports of primary commodities, and heavy reliance on imported secondary goods. Currently, with the emergence of the African Continental Free Trade Area (AfCFTA) and post-2020 realignments of the global supply chains culminating from the corona virus pandemic, there have been increased flows of trade on containers across the Sub-Saharan and North African trade corridors. This has highlighted the need for efficient maritime entry points via deep seaports, capable of handling the surge in trade volumes.

Despite this growing opportunities, severe constraints have limited several countries' maritime logistics, as existing legacy ports have been shown to be inadequate in terms of physical infrastructure for berthing vessels and fleets of containers. From the year 2000 to 2015, major African gateways have operated shallow-draft harbours of less than twelve (12) metres. This restricts port access to smaller feeder vessels, and in the process force costly cargo transshipments through offshore hubs. It is in response to the rise of mega-container ships that many African coastal states including Nigeria, are currently pursuing the development of deep-sea ports. This includes the one about to be developed in Ibaka in Akwa Ibom State, Nigeria, Lekki Deep Sea Port in Nigeria, Tema Port expansion in Ghana, Tanger Med in Morrocco and the Lamu Port in Kenya, with efforts aimed at expanding the draft depths that exceeds between 14.5 and 18.0 meters. It is noted that expanding vessel capacity and draft clearance allows ports to accommodate ultra-large container vessels (ULCVs). This facilitates the creation of economies of scale, increase in liner shipping connectivity, and lowers the freight costs, that have long been a socio-economic burden on African trade balance accounts (Okeke et al, 2025).

Thus, it is portrayed that the ultimate positive economic returns of the expansion of merchandise trade volume and deep seaport investments depend on the operational efficiency of the port, often measured by vessel turnaround time (TAT). This is the total elapsed time from the arrival time of the ship to the departure time after berth operations. This serves as an indicator of terminal coordination and maritime logistics productivity. This study, therefore, investigates how deep seaports influence the gains from globalization of selected African countries.

Statement of the Problem

Notwithstanding significant capital investments in many African countries' deep seaports, aimed at ensuring the expansion of trade volumes, many of still face several critical operational inefficiencies, especially in this notable era of globalisation. This makes it

impossible to establish if current expansion of physical infrastructure at the ports have had any significant effect on the supply chain efficiency and macroeconomic improvements. This is because many known African container terminals in Lagos, Accra, Cape Town, Nairobi and others have often been limited by shallow draft clearances that are less than the globally recognised 12 meters, and other operational hiccups. Also, while the international benchmark ports maintain average vessel turnaround times of under 48 hours, many African container terminals historically experienced vessel waiting times and berth delays ranging from 4 to 10 days due to manual customs clearance, quay equipment bottlenecks, and poor hinterland road transport connections. Extended vessel turnaround times act as an implicit trade tax, inflating demurrage charges, raising import prices, and eroding export competitiveness in international markets.

This asymmetry between deep water maritime capacity and logistics creates merchandise supply chain bottlenecks, and international trade shocks, which distort African economies, thereby preventing them from fully leveraging regional integration under the African Continental Free Trade Area (AfCFTA) framework. This study, therefore, seeks to investigate how deep seaport capacity expansion and digital logistics, and vessel turnaround times influence the merchandise trade volumes of selected African countries.

Objectives of the Study

The main objective of the study is to investigate port capacity, vessel turnaround time, and merchandise trade in selected African Countries: Evidence from panel data. Specific objectives are to:

1. Evaluate the effect of port vessel capacity of deep seaports on merchandise trade volume of selected African countries.
2. Assess the effect of vessel turnaround time of deep seaports on merchandise trade volume of selected African countries.
3. Determine the joint effect of port vessel capacity and vessel turnaround time of deep seaports on merchandise trade volume of selected African countries.

Research Questions

1. What is the effect of deep seaports' vessel capacity on merchandise trade volume of selected African countries?
2. What is the effect of deep seaports' vessel turnaround time on merchandise trade volume of selected African countries?
3. What is the joint effect of deep seaports' vessel capacity and vessel turnaround on merchandise trade volume of selected African countries?

Research Hypotheses

H_{01}: There is no significant effect of deep seaports' vessel capacity on merchandise trade volume of selected African states

H_{02}: There is no significant effect of deep seaports' vessel turnaround time on merchandise trade volume of selected African states.

H_{03}: There is no significant joint effect of the deep seaports' vessel capacity and vessel turnaround time on merchandise trade volume of selected African countries.

Literature Review

Deep Seaport Expansion in Africa

Deep seaport expansion across Sub-Saharan and North Africa represents a structural realignment from shallow, urban-constrained river ports toward deep-water, automated maritime gateways designed to accommodate modern Ultra-Large Container Vessels (ULCVs). In West Africa, Nigeria's operationalization of the Lekki deep seaport which has 16.5 metre draft and Ghana's Tema Port expansion (16.0 metre draft) have distorted albeit positively the regional maritime dynamics by creating deep-water hubs capable of direct transatlantic freights, reducing reliance on offshore feeder transshipments (Ayesu *et al.,* 2023; Okeke *et al.,* 2025).

In East and Southern Africa, deep seaport expansion is heavily driven by hinterland corridor integration and transhipment hub ambitions. Kenya's Lamu Port development (17.5 metre draft) under the LAPSSET corridor framework complements the Port of Mombasa, while Tanzania's Dar es Salaam Maritime Gateway Project (DMGP) deepened berths to 14.5 metres, enabling Panamax vessel handling and linking directly to the electric Standard Gauge Railway (SGR) (Ba & Kim, 2025; Tanzania Ports Authority, 2025). Meanwhile, South Africa's Deep-water Port of Ngqura (16.0 metre draft) and structural upgrades at Durban anchor the nation's position as Southern Africa's premier transshipment hub. Across all six countries, these capital-intensive investments are executed through Public-Private Partnerships (PPPs) with global operators like DP World and others. These are explicitlydesigned to lower ship turnaround times and reduce unit transport costs.

Port Vessel Capacity

Port vessel capacity is the structural, physical, and technical threshold determining the maximum vessel dimensions (Ba & Kim, 2025). It is measured by draft depth clearance, deadweight tonnage (DWT), quay length, and Twenty-Foot Equivalent Unit (TEU) payload, that a seaport can safely berth and service (UNCTAD, 2024). Historically, African coastal gateways were characterized by shallow draft channels, that is less than 12.0 metres. This leads to restricted access to smaller feeder ships and imposed severe trade cost penalties. In response, West African maritime hubs have executed major deep-water transformations to capture maritime economies of scale (Ayesu et al., 2023). Nigeria's Lekki Deep Sea Port provides a 16.5 metres draft designed to accommodate Ultra-Large Container Vessels (ULCVs) carrying up to 18,0000 TEUs, while Ghana's Tema Port expansion offers 16.0 metres of draft depth to handle larger liner calls (Ayesu et al., 2023; Okeke et al., 2025). Similarly, Senegal's construction of the Ndayane deep-water port (18.0-meter draft) overcomes physical spatial constraints at the Port of Dakar, establishing high-capacity terminal facilities capable of servicing next-generation container fleets along the Atlantic corridor (Ba and Kim, 2025).

In East and Southern Africa, vessel capacity expansions are strategically aligned with inland corridor demands and transshipment network growth. Kenya's infrastructure investments at the Port of Mombasa, typified by the Kipevu Oil Terminal 2 170,000 DWT capacity and expanded container terminals, have expanded annual container handling capacity beyond 2.08 million TEUs (UNCTAD, 2024). In Tanzania, the Dar es Salaam Maritime Gateway Project upgraded harbor draft depths to 14.5 meters, enabling direct calls by larger Panamax vessels and significantly boosting throughput efficiency along the Central Corridor (Mlambo, 2021; UNCTAD, 2023). In Southern Africa, South Africa's Deep-water Port of Ngqura 16.0 metre draft and the Port of Durban anchor regional container capacity, maintaining high-volume vessel handling capabilities (Hoffmann *et al.,* 2020). Across all six nations, expanding physical draft clearances and TEU berthing capacity remains essential for reducing

freight rates, eliminating costly offshore transshipments, and maximizing trade under existing trade agreements.

Vessel Turnaround Time

Vessel turnaround time (TAT) is the aggregate elapsed duration from a ship's arrival at port limits to its departure after berth operations (UNCTAD, 2025). This serves as a primary operational indicator of maritime terminal efficiency, quay handling speed, and logistics coordination. While global benchmark ports maintain average vessel turnaround times under 24 to 48 hours, container terminals across Sub-Saharan Africa have historically recorded extended dwell times ranging from 4 to 10 days due to equipment downtime, manual customs clearance, and landside hinterland congestion (World Bank & S&P Global Market Intelligence, 2025). In West Africa, targeted digital reforms and deep-water terminal concessioning have driven notable operational gains; for instance, World Bank evaluations via the Container Port Performance Index (CPPI) highlight significant turnaround improvements at Nigeria's Apapa and Tincan Island ports, alongside Ghana's modernized Tema Port terminal and Senegal's digitalized Dakar gateway, which have reduced vessel waiting times to capture Atlantic shipping traffic (Okeke *et al.*, 2025).

In East and Southern Africa, vessel turnaround performance is heavily moderated by the integration of port terminals with multi-modal transport corridors. Kenya's Port of Mombasa and Tanzania's Port of Dar es Salaam have reduced vessel turnaround times by upgrading berth gantry cranes and connecting automated container yards directly to national Standard Gauge Railway (SGR) networks, mitigating landside cargo evacuation bottlenecks (Mlambo, 2021). Conversely, South Africa's ports, including Durban and Port Elizabeth, have experienced fluctuating turnaround metrics due to legacy equipment breakdowns and extreme weather disruptions, despite dedicated operational recovery programmes (Mlambo, 2021. Across all six nations, adopting Maritime Single Windows (MSW) and expanding deep-draft berthing capacity remain central to shortening vessel turnaround times, reducing shipping demurrage costs, and enhancing trade competitiveness under the African Continental Free Trade Area (AfCFTA) framework (Ayesu *et al.*, 2023).

Merchandise Total Trade Value

Merchandise total trade value is the aggregate sum of gross merchandise exports and imports (FOB/CIF). This serves as a primary metric for evaluating an economy's trade openness, external market integration, and balance-of-payments vulnerability (African Export-Import Bank, 2025). Across Sub-Saharan and North Africa, merchandise trade values remain heavily constrained by a primary commodity export bias, with primary goods (fuels, minerals, and agricultural raw materials) accounting for over 76% of total continental export value, while manufactured goods dominate import inflows (Ayesu *et al.*, 2023).

Among all the countries in Africa, South Africa leads in absolute merchandise trade volume, driven by diversified exports of metals, precious minerals, and automotive manufacturing against capital goods imports. Nigeria's total merchandise trade value is dominated by crude oil and gas exports, creating severe macro-economic exposure to global energy price shocks and persistent non-oil trade deficits (UNCTAD, 2025). The merchandise profile for Ghana is similarly anchored in raw gold, crude oil, and cocoa beans, whereas East African trade gateways like Kenya and Tanzania, exhibit merchandise trade values centred on agricultural exports (tea, coffee, horticulture), gold (Tanzania), and substantial machinery and energy imports needed for national infrastructure development (Mlambo, 2021).

Furthermore, Senegal functions as a key Francophone Atlantic gateway whose merchandise trade values are shaped by refined petroleum, groundnuts, phosphates, and gold exports alongside transit trade for landlocked Sahelian neighbours (UNCTAD, 2026). All the six (6) African countries, expanding regional trade mechanisms under the African Continental Free Trade Area (AfCFTA) and localised payment networks, such as the Pan-African Payment and Settlement System (PAPSS), are designed to reduce external currency dependence, increase intra-African trade value, and transition these economies away from primary commodity extraction toward integrated secondary manufacturing trade (Mlambo, 2021; UNCTAD, 2026).

Theoretical Frameworks

Three theories underpin the investigation of port capacity, vessel turnaround time, and merchandise trade in selected African countries: Evidence from panel data. These are New Economic Geography, Dependency and Human Capital theories.

New Economic Geography (NEG) Theory

This theory was pioneered by P. Krugman (1991) and further expanded in 1996 by Venables, 1996; Krugman, 1991; Fujita *et al.*, 1999. The theory explained how spatial economic structures, industrial agglomeration, and international trade flows are driven by the interaction between scale economies, transportation costs, and market size. The theory argued that economic activity naturally concentrates in specific geographic hubs due to centripetal forces such as backward and forward linkages, pooled labour markets, and technological spillovers. However, the strength of these agglomeration forces depends heavily on trade costs. Accordingly, as transport and logistics costs fall below a critical threshold, firms can centralise production in a hub and service distant peripheral markets efficiently.

In the context of this study with focus on deep seaports, this theory has provided the framework for understanding how port capacity like berth capacity and digital logistics efficiency directly reduce overall maritime transport costs. According to the New Economic Geography (NEG) theory, expanding port draft clearance allows Ultra-Large Container Vessels (ULCVs) to berth, creating economies of scale in maritime shipping. This reduction in unit transport costs expands trade openness and total trade volumes (TRD). Also, automated port logistics reduce vessel turnaround times (TAT), directly boosts maritime logistics Total Factor Productivity (TFP) (Krugman, 1991). This lowers transport costs, enabling coastal nations to integrate into Global Value Chains (GVCs) and serve as regional transshipment hubs.

Dependency Theory

This theory was proposed by Prebisch (1950), Frank (1967), and Amin (1976). The theory posited that the global economic system is structurally divided into a dominant core wealthy industrialised nations and a subjugated periphery developing nations. The theory argues that global trade rules, capital flows, and logistics networks are built to extract raw materials from the periphery while funnelling high-value manufactured goods from the core. When this is applied to maritime economics, often referred to as the Maritime Dependency theory, it highlights how developing states rely passively on foreign-owned shipping lines, foreign maritime technology, and foreign capital to facilitate their trade (Amin, 1976).

The dependency theory has provided a critical lens to evaluate the structural risks of seaport expansion in developing economies. While globalisation promises trade growth, passive integration without domestic maritime ownership can exacerbate economic vulnerability. Hence Dependency theory explains why seaport expansion does not automatically guarantee balanced trade. If African deep

seaports are built primarily via foreign concessionaires to handle containerized imports of foreign manufactured goods and primary commodity exports, then there is the tendency that trade expansion may reinforce an asymmetric trade balance (Prebisch, 1950; Frank, 1967).

Human Capital Theory

This theory was developed by Gary Becker (1964). The theory posited that investments in education, training and skills enhancement directly raise the economic productivity of individuals and nations. In the context of this study, it is argued that physical infrastructure (port capacity) and operational efficiency (vessel turnaround) cannot yield maximum merchandise trade volume and value unless they are matched by qualitative investments in tertiary education, especially a functional Business Education curriculum that produces highly skilled workforce (Ebieme & Daniel, 2026; Ebieme & Enyetip, 2026; Enyetip & Ebieme, 2026).

Empirical Framework

Ba & Kim (2025) examined the impact of maritime connectivity on African container ports efficiency: A continental and regional perspective. The study implemented a two-stage empirical framework across 23 African container ports from 2015 to 2024. Stage one utilized Data Envelopment Analysis (DEA under Variable and Constant Returns to Scale) to calculate technical efficiency scores, while stage two applied panel regression to measure the impact of the Port Liner Shipping Connectivity Index (PLSCI). In the findings, Tanger Med (Morocco), Durban (South Africa), and Tema (Ghana) emerged as the most technically efficient ports on the continent. While PLSCI was a statistically significant driver of efficiency in West-Central Africa ($R^2 = 0.464, p = 0.043$) and North Africa ($R^2 = 0.692, p = 0.040$), scale inefficiencies, rather than external connectivity alone, constituted the primary performance barrier continent-wide. Maritime shipping connectivity is insufficient to drive port efficiency if underlying scale and managerial inefficiencies remain unaddressed.

Quedraogo (2025) conducted a comparative analysis of port efficiency in ECOWAS: Case studies of major ports. The researcher employed a longitudinal Data Envelopment Analysis (DEA using both CCR and BCC models) combined with a SWOT analysis framework to evaluate the technical and scale efficiency of four major ECOWAS gateways, Abidjan, Tema, Lagos, and Lomé from 2011 to 2024. The Port of Lomé demonstrated the highest operational efficiency, consistently achieving optimal CCR and BCC scores of 1.0 by 2024 due to its deep-water capabilities and effective terminal concessions. In contrast, Tema and Lagos exhibited persistent scale inefficiencies, vessel clearance delays, and hinterland transport bottlenecks. The study concluded that Deep-water berthing capacity paired with terminal concessioning forms the cornerstone of competitive advantage in West African port logistics.

Ayesu *et al* (2023) investigated seaport efficiency, port throughput, and economic growth in Africa. The study adopted a dynamic Panel System Generalized Method of Moments (System GMM) estimator on a dataset spanning 28 African coastal states over the period 2010–2018. The econometric model was used in testing for the direct effects of port throughput and the mediating role of seaport efficiency on real GDP growth. Findings showed that there is a direct, statistically significant positive effect of both seaport efficiency and port throughput on economic growth. Specifically, a 1% improvement in seaport efficiency increased economic growth by 0.014% to 0.038%, while a 1% increase in port throughput boosted growth by 0.028% to 0.043%. Furthermore, seaport efficiency significantly magnified the growth-inducing impact of trade throughput.

Mlambo (2021) explored the impact of port performance on trade: The case of selected African states. This study utilized a dynamic panel Autoregressive Distributed Lag (ARDL) estimation technique analysing annual macro-level data across selected African coastal states over the period 2005–2018. Port performance was proxied using median container ship port dwell time and maritime logistics efficiency indicators. The findings confirmed that port performance exerts a statistically significant positive impact on foreign trade volume in both the short run and long run. Severe port congestion, long vessel waiting times, and dilapidated handling equipment were identified as significant structural drags that inflate trade costs and suppress export competitiveness. In conclusion, the researcher stated that inefficient port operations and long container dwell times act as major non-tariff barriers that isolate African economies from global trade networks.

Hoffmann *et al* (2020) investigated liner shipping bilateral connectivity and its impact on South Africa's bilateral trade flows. The study applied Quasi-Maximum Likelihood Estimation (QMLE) to a dynamic panel dataset covering South Africa and 142 global trading partners from 2008 to 2016. Maritime connectivity was decomposed into five distinct liner shipping sub-components alongside geographic distance variables. The findings revealed that the number of common direct shipping connections, carrier competition, and foreign Gross Domestic Product (GDP) had statistically significant positive impacts on bilateral trade flows in both the short and long run. Conversely, transshipments and extended sailing distances exerted strong trade-reducing effects. Interestingly, accommodating ever-larger ship sizes did not yield a statistically significant positive effect on trade flows. In conclusion, direct liner connectivity and carrier competition are far more decisive in promoting foreign trade flows than merely expanding berth capacity for mega-vessels without direct shipping calls.

The review of empirical works on port capacity, vessel turnaround time, and merchandise trade has revealed that studies were carried out on various angles or dimensions of deep seaports, but did not cover the period of 2000-2026. Also, Nigeria was under-researched, not minding the fact that, she is a key player in the sector, with massive trade volumes and vast maritime potentials. Therefore, this study sought to fill the gap identified in the literature by investigating port capacity, vessel turnaround time and merchandise trade in selected African countries: Evidence from panel data.

Methodology

Research Design

Panel-data research design was adopted for the study. This justified the selection of six (6) African countries in investigating port capacity, vessel turnaround time, and merchandise trade (2000-2026). This design supported the use of econometric methods in establishing the effects of port vessel capacity and vessel turnaround times on 3.3 merchandise total trade volumes of these African countries.

Population and Sample of the Study

The population of this study was 52 African countries as provided by the records of African Union. However, the sample of the study was purposively selected based on some established criteria. This was to ensure the empirical validity and cross-sectional comparability. These countries included; Nigeria (Apapa Port Complex), Ghana Port of Tema), Tanzania (Port of Dar es Salaam), Morocco (Tanger Med), Kenya (Port of Mombasa) and South Africa (Port of Durban). The selection criteria included the following:

i. The country must have at least one major operational deep seaport (draft depth greater 14.0 metres) that can accommodate Post-Panamax or Ultra-Large Container Vessels (ULCVs).

ii. The sample must also reflect regional representation across key maritime gateways (West Africa, North Africa and East and Southern Africa).
iii. The selected countries must collectively account for over 60% of total container throughput (TEUs) and transshipment activity in Sub-Saharan and North Africa.
iv. There should be availability of port-level operational time-series data accessible across the period covered in this study (2000-2026).

Sources of Data

Only secondary data was used in this study. The data sources included the selected African countries' Statistical Bulletins and the trade and deep seaports statistics provided by the United Nations Conference on Trade and Development (UNCTAD) for the period covered in the study. The data for 2026 was estimated using interpolation, given the unavailability of the data as of the time of this study.

Model Specification

The specification of model was done with simple and multiple regression functions for the research objectives established in the study. This is presented in the logged forms. The logged forms were specified to reduce any issues emanating from scale of values and trend, like multicollinearity and serial correlation.

Research Objective One

$$\ln(MTV_{it}) = \alpha_0 + \alpha_1 \ln(PVC_{it}) + \varepsilon_{it} \quad \text{Equation 3.1}$$

Research Objective Two

$$\ln(MTV_{it}) = \alpha_0 + \alpha_1 \ln(VTT_{it}) + \varepsilon_{it} \quad \text{Equation 3.2}$$

Research Objective Three

$$\ln(MTV_{it}) = \alpha_0 + \alpha_1 \ln(PVC_{it}) + \alpha_2 \ln(VTT_{it}) + \varepsilon_{it} \quad \text{Equation 3.3}$$

Where:

$i = 1, \dots, N$ represents the selected African states

$t =$ the annual period.

MTV_{it} = Merchandise Trade Value

PVC_{it} = Port Vessel Capacity

VTT_{it} = Vessel Turnaround Times

ε_{it} = Idiosyncratic stochastic disturbance term.

Data Analysis Techniques

Descriptive and inferential statistical techniques were used. This was carried out using Eviews 10.0. For the estimation of the models, panel pooled, Fixed/Random Effects regression method was used. This was established using Hausman specification test. This helped to establish whether the individual country effects (γ_i) are correlated with the regressors, deciding between Fixed Effects ($p < 0.05$) and Random Effects ($p > 0.05$). All the hypotheses were tested at 5% significance level.

Testing of Hypotheses

H01: There is no significant effect of deep seaports' vessel capacity on merchandise trade volume of selected African countries.

Table 1: Panel Regression Result for Vessel Container Capacity (VCC) and Merchandise Trade Volume (MTV)

Variable / Statistic	Pooled OLS	FE (classical SE)	FE (Driscoll-Kraay)
ln(Vessel Container Capacity)	0.5528***	1.2281***	1.2281***
Std. Error	(0.0277)	(0.0179)	(0.0046)
t-statistic	[19.9705]	[68.5441]	[267.4158]
p-value	0.0000	0.0000	0.0000
Constant	-3.4030***	-12.7118***	-12.7118***
Std. Error	(0.3820)	(0.2470)	(0.0644)
t-statistic	[-8.9085]	[-51.4580]	[-197.5265]
p-value	0.0000	0.0000	0.0000
R-squared	0.7137	0.9681	0.9681
F-statistic / Wald χ^2	398.82***	4698.29***	4698.29***
Observations (N×T)	162	162	162

Source: Author's computation EVIEWS 2026

Poolability ($F(5,155) = 367.32$, $p < 0.001$)

Table 1 indicates that all the merchandise trade volume (MTV) will be equal to -3.4030 if the vessel container capacity (VCC) of certain selected African countries studied is unchanged (VCC=0) under Pooled OLS. According to this specification, a 1% increase in VCC will result in a 0.5528% increase in MTV. This means VCC has a positive impact on MTV of the African states and the impact is statistically significant at 1% level of significance (p-value = 0.0000). The value of R^2 of 0.7137 shows that 71.37% of the variations of MTV are explained in the Pooled OLS model with VCC, and the remaining 28.63% of the variations are explained by the other factors which are included in the error term. Since the obtained value of the F Statistic (398.82) falls short of the critical value (p = 0.0000), there is no reason to reject the null hypothesis.

Next, the analysis re-focuses on Pooled OLS, but also adjusts for country-specific heterogeneity, as captured by the entity Fixed Effects specification, across the six countries chosen for Africa. Fixed Effects eliminates the constant changes to -12.7118, and the coefficient on VCC increases to 1.2281, which is an increase from the previous 1.1708%, showing that for every 1% increase in VCC, MTV increases by 1.2281% when country specific differences are held constant. This latter effect is still statistically significant at the 1% level (p = 0.0000). This is an improvement over the 71.37% of MTV accounted for when country effects are absorbed by the Pooled OLS model ($R^2 = 0.7137$).

The coefficient on VCC does not change from the classical Fixed Effects estimate of 1.2281% to the corrected estimate under Driscoll-Kraay standard errors of 1.2281% (p = 0.0000). Only the standard error gets smaller, from 0.0179 under classical Fixed Effects to 0.0046 under the Driscoll-Kraay correction. The R^2 remains at 0.9681. Hence, for all three specifications, the null hypothesis is rejected and it is concluded that there is a statistically significant positive effect of vessel container capacity on the trade volume of merchandise in the selected African countries.

It is clear that Hausman Specification Test was not computed for this model. The Hausman test is implemented by comparing the coefficient estimates from the Fixed Effects model and the Random Effects model, and the difference in the variance-covariance matrices of both models, which involves inverting a variance-difference matrix generated from the two models. This panel, however, has only 6 cross-sectional units (countries) and thus that matrix did not turn out to be positive definite, as is known to be the case in the Hausman test when the number of cross-sectional units is relatively small compared to the number of the parameters estimated. This is not a mathematical error but a limitation of the test

in this panel design and no valid chi square statistic could be calculated. Thus, the choice between Fixed-Effects and Random-Effects for this hypothesis is based on the poolability F-test, which usefully rejects the assumption of pooling ($F(5,155) = 367.32$, $p < 0.001$), and on the significant differences between the Pooled OLS and Fixed-Effects coefficients (0.5528 versus 1.2281), rather than on a completed Hausman test.

H02: There is no significant effect of deep seaports' vessel turnaround time on merchandise trade volume of selected African countries.

Table 2: Panel Regression Result for Vessel Turnaround Time (VTT) and Merchandise Trade Volume (MTV)

Variable / Statistic	Pooled OLS	FE (classical SE)	FE (Driscoll-Kraay)
ln(Vessel Turnaround Time)	-2.8891***	-3.6196***	-3.6196***
Std. Error	(0.0861)	(0.0728)	(0.0260)
t-statistic	[-33.5437]	[-49.6996]	[-139.3546]
p-value	0.0000	0.0000	0.0000
Constant	15.6368***	18.5240***	18.5240***
Std. Error	(0.3406)	(0.2879)	(0.0995)
t-statistic	[45.9034]	[64.3308]	[186.2228]
p-value	0.0000	0.0000	0.0000
R-squared	0.8755	0.9410	0.9410
F-statistic / Wald χ^2	1125.18***	2470.05***	2470.05***
Observations (N×T)	162	162	162

Source: Author's computation EVIEWS 2026

Poolability F-test ($F(5,155) = 62.68$, $p < 0.001$)

Table 2 reveals that in the absence of any changes in vessel turnaround time (VTT = 0) of the selected African countries studied, merchandise trade volume (MTV) will remain constant at 15.6368 under Pooled OLS. The relationship between VTT and MTV is negative and statistically significant with an increase of 1% in VTT there is a decrease of 2.8891% in MTV. Under Pooled OLS, the R^2 value of 0.8755 suggests that, 87.55% of the variations in MTV are explained by VTT and 12.45% is explained by other factors. The result of this test is not included in the null hypothesis ($p < 0.05$), thus the influence of VTT on MTV is statistically significant and negative.

The analysis then moves from Pooled OLS to the entity Fixed Effects specification. With Fixed Effects, the constant becomes 18.5240, and the coefficient associated with VTT becomes more negative (-3.6196): When country-specific effects are controlled for, a 1% increase in VTT is related to a greater 3.6196% decrease in MTV. This coefficient is still significant at the level of 1% ($p = 0.0000$). The R^2 increases to 0.9410, meaning that 94.10% of the MTV's within-country variation is explained by VTT after the country effects have been absorbed, compared to 87.55% when the country effects are absorbed through Pooled OLS. Again, the null hypothesis is rejected ($p < 0.05$) supporting the existence of a significant negative effect of VTT on MTV within countries.

Under the same Driscoll-Kraay standard errors corrected for cross sectional dependence and serial correlation, the coefficient on VTT is the same (-3.6196%) and the effect remains statistically significant at 1% level ($p = 0.0000$); the standard error is reduced from 0.0728 (Fixed Effects) to 0.0260 (Driscoll-Kraay). The R^2 remains at 0.9410. Under the three specifications, the null hypothesis is rejected, and the strong negative relationship between VTT and MTV is validated: All three

specifications show a statistically significant negative relationship between VTT and the merchandise trade volume of the selected African countries.

The Hausman Specification Test could not be calculated for this model as in the case of Hypothesis One. Again, the small-N caveat applies: If there are 6 countries in the panel, the variance-difference matrix used to calculate the Hausman χ^2 statistic is not positive definite, and a reliable statistic is not possible. This is not sugar coated. It does not mean that the choice of Fixed Effects for this hypothesis (as with Hypothesis One) is made based on a formally completed Hausman comparison but rather the poolability F-test ($F(5,155) = 62.68$, $p < 0.001$), which fails to pool, and the size of the coefficient shift between Pooled OLS and Fixed Effects (-2.8891 versus -3.6196). For the purpose of reporting a valid Hausman statistic for this relationship, a larger cross-sectional sample would be needed than the one for which data is available, 6 countries in this case.

H03: There is no significant joint effect of deep seaports' vessel capacity and vessel turnaround time on merchandise trade volume of selected African countries.

Table 3: Panel Regression Result for Vessel Container Capacity (VCC), Vessel Turnaround Time (VTT) and Merchandise Trade Volume (MTV)

Variable / Statistic	Pooled OLS	FE (classical SE)	FE (Driscoll-Kraay)
ln(VCC)	-0.0971**	1.0792***	1.0792***
Std. Error	(0.0478)	(0.0926)	(0.1435)
t-statistic	[-2.0329]	[11.6483]	[7.5224]
p-value	0.0437	0.0000	0.0000
ln(VTT)	-3.3131***	-0.4537	-0.4537
Std. Error	(0.2253)	(0.2770)	(0.4354)
t-statistic	[-14.7028]	[-1.6383]	[-1.0421]
p-value	0.0000	0.1034	0.2990
Constant	18.6509***	-8.8652***	-8.8652**
Std. Error	(1.5206)	(2.3608)	(3.6981)
t-statistic	[12.2656]	[-3.7552]	[-2.3972]
p-value	0.0000	0.0002	0.0177
R-squared	0.8787	0.9686	0.9686
F-statistic / Wald χ^2	575.67***	2376.01***	2376.01***
Observations (N×T)	162	162	162

Source: Author's computation EVIEWS 2026

Hausman Specification Test: $\chi^2(2) = 394.70$, $p < 0.001$ — Fixed Effects confirmed over Random Effects

Poolability F-test: $F(5,154) = 139.84$, $p < 0.001$

Table 3 indicates that the value of merchandise trade volume (MTV) will be constant (18.6509) if there is no change in Vessel container capacity (VCC) and Vessel turnaround time (VTT) in the selected African countries studied (VCC = 0, VTT = 0). Pooled OLS indicates that an increase by 1% in VCC is followed by a 0.0971% decrease in MTV, which is significant at the 5% level ($p = 0.0437$), whilst an increase by 1% in VTT results in MTV decreasing by 3.3131%, which is significant at the 1% level ($p = 0.0000$). In Pooled OLS, VCC and VTT explain only 87.87% of the variation in MTV, while the other part of the variation, 12.13%, is explained by other factors. The two-way interaction of VCC and VTT is statistically significant (F-statistic = 575.67, $p < 0.05$), and confirms that there is a statistically significant relationship between VCC and VTT together with MTV.

The analysis then moves on from Pooled OLS to the entity Fixed Effects specification, where country-specific heterogeneity is controlled for. Even after controlling for country specific fixed effects, the coefficient estimate for VCC is significant and positive, at 1.0792%, while in Pooled OLS it was significant and negative at -0.0971%. These results indicate that capacity has a positive effect on trade volume once country level differences are properly controlled for. This coefficient is significant at 1% level ($p = 0.0000$). However, the same coefficient for VTT is found to be less in magnitude, at -0.4537% and is not statistically significant ($p = 0.1034 > 0.05$). The R^2 increases to 0.9686 indicating that 96.86% of the within-country variation in MTV can be accounted for by the combined effects of VCC and VTT, and the rest, 3.14%, could not be explained. For VCC, the null hypothesis was rejected ($p < 0.05$), thus providing statistical evidence for a positive effect on MTV after controlling country effects. In this combined specification, the null hypothesis is not rejected ($p > 0.05$) and the effect of turnaround time on the outcome is not statistically significant at the combined level, after the country-specific (and vessel capacity) effects are taken into account.

It is important to remember that the coefficient on VCC is not changed when applying Driscoll-Kraay standard errors to correct for cross-sectional dependence and serial correlation, and this effect is still significant at the 1% level ($p = 0.0000$). The coefficient is still at -0.4537% with the p-value increasing further to 0.2990 which still exceeds the 0.05 threshold, which is why the null hypothesis for VTT is not rejected for this strong specification. The R^2 remains at 0.9686. The overall joint model (F-statistic = 2376.01, $p < 0.001$) is still very significant when we consider the joint model along with the capacity variable, but it should be explicitly stated that the contribution of vessel turnaround time within this considered joint model and country-controlled specification is not statistically distinguishable from zero, although turnaround time was independently significant within this specific country-controlled specification in Hypothesis Two.

The Hausman Specification Test for this joint model, unlike Hypotheses One and Two, could be calculated in a straightforward manner: $\chi^2(2) = 394.70$, $p < 0.001$. This is because the two-variable joint model yields a larger and more stable variance-difference matrix than the single-variable models presented above do in the event of a small N computational breakdown in Hypotheses One and Two. The Formal Test of Poolability in a Joint Model confirms that the Random Effects alternative does not provide a statistically superior model for the current model, and thus is not pooled—consistent with the F-test for Poolability, which rejected poolability ($F(5,154) = 139.84$, $p < 0.001$).

Discussion of Findings

The empirical findings generated from the panels regression analysis provides insights into the importance of the relationships between deep seaports vessel capacity (VCC), deep seaports' vessel turnaround time (VTT) and merchandise trade volume (MTV) for selected African countries. Table 1 shows that the regression results for all three specifications (Pooled OLS, Fixed Effects (FE) and Fixed Effects with Driscoll-Kraay standard errors) indicate that there is a statistically significant positive relationship between vessel container capacity (VCC) and merchandise trade volume (MTV). Specifically, VCC has a positive effect of 1% on MTV with the coefficient being 0.5528% under Pooled OLS and increases to 1.2281% under Fixed Effects models. This finding aligns with that of Ayesu et al. (2023) and Ba & Kim (2025) who were able to show that physical upgrades of port facilities, specifically by increasing the port's draft (the depth of water in the port), had a direct positive impact on the capacity of vessels to carry containers and in turn, the performance of the national trade. In the 2 sets of results, the high R-squared values (0.7137 for Pooled OLS and 0.9681 for Fixed Effects) substantiate the fact that VCC accounts for a significant amount of the variation in MTV, this is further

support for the importance of deep-water port capacity in reducing freight costs and economies of scale in maritime transport. This is in line with the New Economic Geography theory (Krugman, 1991; Venables, 1996) which states that a reduction in transport costs due to infrastructure development will allow the coastal countries to become part of global value chains (GVCs) in order to act as regional transshipment centres.

Effect of Deep Seaports' Vessel Turnaround Time on Merchandise Trade Volume

Table 2 shows that the results indicate that there is a statistically significant negative correlation between the vessel turn around time (VTT) and merchandise trade volume (MTV). Under Pooled OLS, this translates to an MTV decrease by 2.8891% with a VTT increase by 1% whereas it is more pronounced under Fixed Effects models with a decrease of 3.6196% in MTV with an increase of 1% in VTT. The negative correlation found is in agreement with the findings of Mlambo (2021) which indicated that "extended vessel dwell times and administrative delays are an implicit trade tax, add to the delay of the schedules in the supply chain and reduce export competitiveness. These high R-SQUARES (Pooled OLS: 0,8755 and Fixed Effects: 0,9410) also support the relationship between VTT and MTV since the variability of MTV can be explained by a large portion of the variability in VTT.

All the results are significant statistically for all of the specifications with $p = 0.0000$ which is in contrast to the null hypothesis (H02) which confirms that VTT has strong negative effect on MTV. This aligns with the World Bank & S&P Global Market Intelligence (2025) report which indicated that prior to the implementation of the NewCOST, the waiting time of ships at ports in Africa ranged between 4 and 10 days; a period that also impacted trade competitiveness driven by manual customs clearance process and hinterland congestion. For faster vessel turnaround times and enhanced trade productivity, particularly at Nigerian ports like Apapa and Tincan Island, the elimination of manual reforms and automated clearance processes are crucial (Okeke et al. 2025).

Joint Effect of the Deep Seaports' Vessel Capacity and Vessel Turnaround Time on Merchandise Trade Volume

The results of this study showed that the capacity of vessels and the turnaround time of vessels had a significant effect on the quantity of merchandise trade (MTV). Under Pooled OLS, a 1% increase in VCC leads to a 0.0971% decrease in MTV ($p = 0.0437$), while a 1% increase in VTT leads to a 3.3131% decrease in MTV ($p = 0.0000$). But, after controlling for the country-specific heterogeneity (Fixed Effects), the coefficient for VCC becomes positive and highly significant (1.0792%, $p = 0.0000$), while VTT gets less significance (-0.4537%, $p = 0.1034$). The change reminds the need to take into account the country-specific dimension of the impact of maritime infrastructure and its efficiency on trade.

The Hausman Specification Test ($\chi^2(2) = 394.70$, $p < 0.001$) is used to decide which of the two types of models (Fixed Effects or Random Effects) is the best fit. The null hypothesis (H03) is rejected and the significance of the joint model of VCC and VTT for the explanation of MTV is confirmed in a Fixed Effects model. This also supports the claims of Ba & Kim (2025) and Mlambo (2021) that it is the combination of physical maritime infrastructure (e.g., draft depth, quay length), and operational efficiency (e.g., turnaround speed, digital clearance) that are complementary pillars of supply chain performance. Expanding the port is not always enough to achieve the optimum level of trade volumes when the clearances along the landside to the port are restricted and/or vessels are queuing on the water. Thus, the complementary development of both the VCC and the VTT is key to ensure optimal merchandise trade flows, and maximise the economic dividend of globalization and regional integration under AfCFTA.

Furthermore, the findings of this study carry profound implications for institutional human capital development, particularly within the domain of university-level Business Management and Business Education. While the statistical indices prove that expanding port capacity and minimizing vessel turnaround times are vital drivers of merchandise trade value, these macro-economic variables remain fundamentally dependent on the human infrastructure driving maritime logistics operations. Consequently, these findings expose a critical gaps-in-knowledge pipeline between current tertiary business classroom instruction and real-world global trade demand. Bridging this divide requires an urgent pedagogical shift where Management and Business Education departments transition from teaching generic administrative processes to integrating advanced data-driven competencies in supply chain mechanics, automated customs clearing metrics, and maritime trade and management into their frameworks (Bassey & Ebieme, 2026; Ebieme & Bassey, 2026; Ebieme & Udida, 2026; Ebieme, 2026).

Conclusion and Recommendations

The findings in the study have demonstrated that maritime infrastructure expansion and operational logistics efficiency serve as catalysts for driving international trade integration via globalisation across selected African coastal countries. While increasing port vessel capacity through deep-water draft expansion confers economies of scale and creates direct calls by modern container fleets, significant reduction in vessel turnaround times through streamlined clearance processes decimates the high friction costs that historically suppressed African export competitiveness despite the purported gains of globalisation. Hence, the statistically significant joint effect confirms that physical deep-seaport capacity upgrades and digital, operational turnaround speed must be advanced in synergy to optimise merchandise trade flows and fully realise the economic imperatives of globalisation and regional market integration under the AfCFTA initiatives.

Based on the findings and conclusion of the study, the following recommendations are made:

1. African countries should accelerate deep seaport infrastructural development through increased capital investments. This will open many of these countries to international trade flows that would be very beneficial. An example is the Ibaka Deep Seaport in Akwa Ibom, which will help increase trade flows to the South-South part of Nigeria and its environs.
2. Maritime authorities in African countries should deploy without delay digital single window and automated clearance systems in their ports. This will minimise demurrage fees and reduce ship stay durations, leading to increased trade advantage.
3. African countries maritime policymakers should develop and harmonise deep seaport expansions through multi-modal hinterland connectivity that synchronises with rail and dry port linkages. This will ensure high-capacity maritime trade volumes across Africa. Ultimately, Ministries of Education, University Governing Councils, and Curriculum Planners should collaborate to launch a comprehensive review of Management and Business Education curriculum. This intervention should systemically scrap obsolete operational models and replace them with specialized, industry-aligned modules focusing on digital logistics management, international trade operations, and predictive analytics. By executing this instructional overhaul, universities will successfully shift from producing passive certificate holders to deploying highly skilled, market-ready Management and Business Education graduates who can actively optimize port administrative ecosystems and sustainably accelerate Sub-Saharan trade volume and value.

Implications of the Study

Policy and Managerial Implications

The empirical findings of this study offer critical insights for maritime policymakers, port authorities, and logistics managers seeking to optimize trade performance across the selected African countries. First, the significant impact of vessel turnaround time on merchandise trade volume and value implies that national government should prioritise investments in smart port technologies and automated clearing bottlenecks and adopting single-window customs systems will accelerate ship processing times, thereby cutting operational costs for international; shipping lines. Second, because port capacity directly influences trade volume, port managers should expand terminal infrastructure, upgrade deep-water berths, and invest in modern cargo-handling equipment like automated gantry cranes to accommodate larger modern vessels. Finally, regional trade authorities should harmonise maritime policies across borders to eliminate transit delays. By expanding capacity and cutting vessel turnaround times, African port authorities can lower the cost of doing business, integrate their economies into global supply chains, and significantly maximize national merchandise trade volume and value.

Implications for Business Education Curriculum

The findings of this study offer critical insights for the development of the Business Education curriculum, particularly regarding how tertiary institutions prepare students for modern global trade. While traditional Business Education programmes focus heavily on manual administrative procedures and static trade documentation, the results of this study demonstrate that macro-level trade volume and value are directly constrained by operational port efficiencies, such as capacity and vessel turnaround times. Consequently, there is an urgent need to pivot the Business Education curriculum away from routine clerical training toward instruction in digital supply chain analytics and automated port management systems. Integrating these contemporary logistics technologies into international business tracks ensures that graduates possess the practical competencies required to navigate modern maritime bottlenecks. Ultimately, this curriculum bridges the gap between classroom instruction realities of African trade, equipping future entrepreneurs to minimize logistics delays and maximize commercial value.

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