Maritime Shipping Operations and Human Development in Nigeria: The Moderating Role of Infrastructure Development

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ABSTRACT

Maritime transportation remains a critical catalyst for international trade, economic integration, and socio-economic development, particularly in developing economies where trade and logistics serve as important drivers of growth and welfare. Despite the strategic importance of Nigeria's maritime sector, limited empirical evidence exists on the extent to which shipping operations contribute to human development outcomes. This study investigates the impact of maritime shipping operations on human development in Nigeria and evaluates the moderating role of infrastructure development over the period 1990–2025. Specifically, the study examines the effects of Container Shipping Operations (CSO), Bulk Cargo Shipping Operations (BCSO), Tanker Shipping Operations (TSO), and Liquid Cargo Shipping Operations (LCSO) on the Human Development Index (HDI). Infrastructure Development (IND) is incorporated as a moderating variable to determine whether improvements in maritime and transport infrastructure enhance the developmental impact of shipping activities.

The study adopts an ex-post facto research design and utilizes annual time-series data sourced from maritime and development-related institutions. The Autoregressive Distributed Lag (ARDL) approach is employed to estimate both short-run and long-run relationships among the study variables. The Bounds Cointegration Test confirms the existence of a stable long-run equilibrium relationship between maritime shipping operations and human development. Empirical findings reveal that all categories of shipping operations exert positive and statistically significant long-run effects on human development. Bulk Cargo Shipping Operations emerged as the strongest contributor to human development, reflecting its extensive linkages with agriculture, manufacturing, industrial production, and infrastructure development. Container Shipping Operations enhance trade efficiency and market integration, while Tanker Shipping Operations promote human development through export earnings, foreign exchange generation, and government revenue mobilization. Liquid Cargo Shipping Operations contribute through energy security, industrial expansion, and export diversification.

The moderation analysis indicates that infrastructure development significantly strengthens the positive effects of container shipping, bulk cargo shipping, and tanker shipping on human development. These findings underscore the importance of efficient ports, transport networks, logistics systems, and supporting infrastructure in transforming maritime activities into broader welfare gains. The study concludes that maritime shipping operations constitute an important pathway through which trade expansion, employment creation, industrial growth, and investment translate into improvements in health, education, income, and living standards. It recommends increased investment in port modernization, multimodal transport connectivity, maritime logistics infrastructure, digital port systems, and human capital development within the maritime sector to maximize the contribution of shipping operations to sustainable human development in Nigeria.

Keywords: Maritime Shipping Operations, Human Development, Infrastructure Development, Container Shipping, Bulk Cargo Shipping, Tanker Shipping, Liquid Cargo Shipping, ARDL, Nigeria.

1. INTRODUCTION

Maritime transportation is widely recognized as the backbone of global commerce and one of the most important facilitators of international economic integration. It serves as the primary means through which

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goods, commodities, energy resources, and industrial inputs are exchanged across national boundaries. The efficiency of maritime transport systems significantly influences trade competitiveness, investment flows, industrial productivity, and economic performance. Beyond its economic significance, maritime transportation increasingly plays an important role in facilitating broader development outcomes by supporting employment generation, income growth, infrastructure expansion, and social welfare improvement.

For developing countries, the maritime sector represents a strategic instrument for economic transformation and sustainable development. Efficient shipping operations reduce transportation costs, improve access to global markets, stimulate industrial activities, attract investment, and facilitate the movement of strategic commodities necessary for production and consumption. Consequently, maritime transportation has become an essential component of national development strategies aimed at improving competitiveness and integrating domestic economies into global value chains.

Nigeria possesses one of the largest maritime domains in Africa, with an extensive coastline of approximately 853 kilometres along the Gulf of Guinea and significant offshore oil and gas resources. The country's ports, including Apapa, Tin Can Island, Onne, Port Harcourt, Warri, and Calabar, serve as critical gateways for international trade and facilitate the movement of millions of tonnes of cargo annually. The maritime sector supports major economic activities through the transportation of containerized goods, industrial inputs, agricultural products, crude oil, petroleum products, and liquefied natural gas.

Over the past three decades, Nigeria has experienced substantial growth in shipping activities driven by trade liberalization, increasing container traffic, expansion of crude oil exports, growth in liquefied natural gas shipments, and investments in port infrastructure. These developments have strengthened the contribution of maritime transportation to economic growth and government revenue generation. Nonetheless, improvements in human development outcomes have not always matched the pace of growth within the maritime sector.

Despite its strategic importance and significant contribution to national output, Nigeria continues to face persistent developmental challenges. High levels of poverty, unemployment, income inequality, poor healthcare services, educational deficits, and inadequate infrastructure remain major constraints to sustainable development. This situation raises important questions regarding the extent to which maritime shipping activities contribute to human welfare and whether the benefits generated by the sector effectively translate into improvements in living standards and quality of life.

The concept of human development extends beyond economic growth and emphasizes the expansion of people's capabilities, opportunities, and freedoms. According to the human development paradigm, economic activities are meaningful only when they contribute to improvements in health, education, income, and overall welfare. The Human Development Index (HDI), which combines indicators relating to life expectancy, educational attainment, and income, provides a comprehensive measure of development that goes beyond conventional economic indicators. Consequently, understanding how maritime shipping operations influence human development has become increasingly important for policymakers seeking sustainable and inclusive development outcomes.

Maritime shipping operations contribute to development through multiple channels. Container shipping facilitates trade expansion and market integration by enabling the efficient movement of manufactured goods and consumer products. Bulk cargo shipping supports industrial production, agriculture, and infrastructure development through the transportation of raw materials and strategic commodities. Tanker shipping enables the exportation of crude oil and petroleum products, thereby generating foreign exchange earnings and government revenue. Liquid cargo shipping supports energy security, industrial diversification, and technological advancement through the transportation of liquefied natural gas, chemicals, and refined petroleum products.

Although these shipping activities contribute significantly to economic performance, their developmental impacts may differ due to variations in their operational structures, economic linkages, employment generation potential, and contributions to productive sectors. However, most previous studies have treated maritime

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transportation as a single aggregate variable, leaving limited understanding of how specific shipping segments contribute to human development outcomes.

In addition, the effectiveness of maritime shipping operations depends significantly on the quality of supporting infrastructure. Ports, terminals, rail systems, roads, logistics facilities, warehousing systems, and digital transport networks influence the efficiency of cargo movement and determine the extent to which shipping activities generate economic and social benefits. Efficient infrastructure reduces logistics costs, enhances trade competitiveness, improves connectivity, and creates opportunities for productive economic activities. Consequently, infrastructure development may strengthen the relationship between maritime shipping operations and human development.

Despite the growing importance of the maritime sector, empirical studies examining the direct relationship between shipping operations and human development remain relatively scarce, especially in developing economies. Even fewer studies have investigated the moderating role of infrastructure development in this relationship. This represents a significant gap in maritime economics and development literature.

Against this backdrop, this study investigates the impact of Container Shipping Operations (CSO), Bulk Cargo Shipping Operations (BCSO), Tanker Shipping Operations (TSO), and Liquid Cargo Shipping Operations (LCSO) on Human Development Index (HDI) in Nigeria while examining the moderating role of Infrastructure Development (IND). By adopting a disaggregated approach to shipping operations and incorporating infrastructure development as a moderating variable, the study provides a richer understanding of how maritime activities contribute to improvements in human welfare.

The study contributes to the literature in four important ways. First, it extends maritime transport research beyond conventional economic growth indicators to a human development perspective. Second, it disaggregates shipping operations into their major components to identify their individual developmental contributions. Third, it incorporates infrastructure development as a moderating variable, thereby highlighting the conditions under which maritime activities generate greater welfare outcomes. Finally, it provides both short-run and long-run evidence using the ARDL framework, offering important policy insights for maritime sector development and sustainable human development in Nigeria.

1.1 Aim of the Study

The primary aim of this study is to examine the effect of maritime shipping operations on human development in Nigeria and to investigate the moderating role of infrastructure development in enhancing the contribution of maritime activities to socio-economic welfare between 1990 and 2025.

The study is motivated by the growing recognition that maritime transport extends beyond its traditional role of moving goods and facilitating trade. As a strategic component of national development, maritime shipping operations generate employment opportunities, increase income levels, stimulate industrial growth, attract investments, promote trade competitiveness, and generate government revenue that can be invested in education, healthcare, and social welfare programmes.

Despite the significant expansion of Nigeria's maritime sector over the past three decades, improvements in human development outcomes have remained relatively modest. Consequently, there is a need to determine whether increases in shipping activities have translated into measurable improvements in health, education, income, and overall living standards. The study therefore seeks to provide empirical evidence on how different categories of shipping operations contribute to human development and whether infrastructure development enhances these contributions.

Specifically, the study focuses on Container Shipping Operations (CSO), Bulk Cargo Shipping Operations (BCSO), Tanker Shipping Operations (TSO), and Liquid Cargo Shipping Operations (LCSO), while Human Development Index (HDI) serves as the indicator of human development. Infrastructure Development (IND) is incorporated as a moderating variable to capture the extent to which efficient ports, transport networks,

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logistics facilities, and supporting maritime infrastructure strengthen the developmental outcomes of shipping activities.

Ultimately, the study aims to provide policy-relevant insights that will assist government agencies, maritime

regulators, infrastructure planners, and development institutions in leveraging maritime transportation as a vehicle for sustainable human development in Nigeria.

Objectives of the Study

To achieve the broad aim of the study, the following specific objectives are pursued:

1. To examine the effect of Container Shipping Operations (CSO) on Human Development Index (HDI) in Nigeria.
2. To evaluate the impact of Bulk Cargo Shipping Operations (BCSO) on Human Development Index (HDI) in Nigeria.
3. To assess the influence of Tanker Shipping Operations (TSO) on Human Development Index (HDI) in Nigeria.
4. To determine the effect of Liquid Cargo Shipping Operations (LCSO) on Human Development Index (HDI) in Nigeria.
5. To examine the moderating role of Infrastructure Development (IND) in the relationship between maritime shipping operations and human development in Nigeria.
6. To evaluate the short-run and long-run dynamics between maritime shipping operations and human development.
7. To provide policy recommendations for enhancing the contribution of maritime transportation to sustainable human development in Nigeria.

2. LITERATURE REVIEW

2.1 Maritime Shipping Operations

Maritime shipping operations constitute the core of international trade and global supply chain management. They encompass all activities involved in the transportation of cargo and commodities through maritime routes using vessels, ports, terminals, logistics facilities, and supporting infrastructure. Shipping operations play a critical role in facilitating trade, supporting industrial production, promoting market integration, generating employment, and fostering economic development.

As one of the most efficient and cost-effective modes of transportation, maritime shipping accounts for the movement of most of the global merchandise trade. For developing economies such as Nigeria, shipping operations are particularly important because they provide access to international markets, facilitate imports and exports, support industrial production processes, and stimulate investment and economic growth.

Maritime shipping operations can be broadly categorized into container shipping operations, bulk cargo shipping operations, tanker shipping operations, and liquid cargo shipping operations. Each category performs distinct economic functions and contributes differently to development outcomes.

Container Shipping Operations

Container shipping involves the transportation of goods in standardized containers designed for efficient handling and intermodal transport. The emergence of containerization revolutionized global trade by reducing

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cargo handling costs, improving logistics efficiency, minimizing cargo losses, and accelerating the movement of goods across international markets.

Container shipping facilitates the transportation of manufactured products, machinery, consumer goods, industrial equipment, pharmaceuticals, and processed agricultural products. Consequently, it enhances international trade, promotes market accessibility, improves supply chain efficiency, and stimulates commercial activities.

By lowering transportation costs and improving connectivity between producers and consumers, container shipping supports industrial expansion, business growth, and employment generation. These outcomes contribute indirectly to human development through increased income generation, improved living standards, and enhanced economic opportunities.

Bulk Cargo Shipping Operations

Bulk cargo shipping involves the transportation of large quantities of unpackaged commodities such as grains, fertilizer, cement, coal, iron ore, agricultural produce, and industrial raw materials.

The importance of bulk cargo shipping lies in its ability to support productive sectors of the economy, particularly agriculture, mining, manufacturing, construction, and infrastructure development. Efficient movement of bulk commodities ensures the availability of critical production inputs required for industrial activities and economic growth.

Bulk cargo transportation contributes significantly to human development because it supports food security, industrial productivity, infrastructure development, and employment generation. Increased availability of raw materials stimulates production, creates economic opportunities, and improves household welfare. The strong linkages between bulk cargo shipping and productive sectors explain why it frequently exerts a stronger developmental impact than other categories of shipping operations.

Tanker Shipping Operations

Tanker shipping operations involve the transportation of crude oil, petroleum products, and other energy commodities using specialized vessels designed for liquid cargo transportation.

For Nigeria, tanker shipping is particularly important because crude oil exports have historically remained the primary source of foreign exchange earnings and government revenue. Through the exportation of crude oil and petroleum products, tanker shipping contributes significantly to national income, balance of payments stability, and public finance.

The developmental significance of tanker shipping arises from its capacity to generate resources that can be invested in social services and public infrastructure. Revenue generated from petroleum exports provides funding for education, healthcare, transportation infrastructure, and poverty reduction programmes. Consequently, efficient tanker shipping operations can contribute to improvements in human development outcomes.

Liquid Cargo Shipping Operations

Liquid cargo shipping encompasses the transportation of liquefied natural gas (LNG), liquefied petroleum gas (LPG), chemicals, refined petroleum products, petrochemicals, and other liquid commodities.

The increasing importance of the global energy sector has elevated the significance of liquid cargo shipping as a driver of industrial development and economic diversification. In Nigeria, LNG exports and related energy products have become increasingly important sources of export earnings and industrial growth.

Liquid cargo shipping supports energy security, technological advancement, industrial expansion, and export diversification. It also facilitates the availability of energy resources required for production, transportation,

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manufacturing, and service delivery. Through these mechanisms, liquid cargo shipping contributes to employment creation, income generation, and improvements in welfare and living standards.

2.2 Human Development

Human development refers to the process of expanding people's capabilities, opportunities, and freedoms to lead productive, healthy, and meaningful lives. Unlike traditional development approaches that focus primarily on economic growth, the human development approach emphasizes the improvement of people's well-being and the enhancement of their quality of life.

The concept gained prominence through the works of Mahbub ul Haq and Amartya Sen and was institutionalized through the Human Development Reports published by the United Nations Development Programme (UNDP). According to this perspective, development should ultimately be measured by the extent to which people are able to live healthier, more educated, and more prosperous lives.

Human development focuses on expanding people's choices and enhancing their access to opportunities that improve their welfare. It recognizes that economic growth is important but should serve to improving human well-being rather than an end in itself.

The Human Development Index (HDI)

The Human Development Index (HDI) is the most widely used measure of human development. It captures three fundamental dimensions of human welfare:

Health

The health dimension is measured through life expectancy at birth and reflects people's ability to live long and healthy lives. Improved health outcomes contribute to higher productivity, better quality of life, and increased economic participation.

Education

The education dimension measures access to knowledge and learning opportunities through indicators such as expected years of schooling and mean years of schooling. Education improves human capabilities, increases employability, promotes innovation, and supports socio-economic mobility.

Income

The income dimension reflects the command individuals have over resources needed to achieve a decent standard of living. It is commonly measured through Gross National Income (GNI) per capita. Higher income levels improve access to healthcare, education, housing, nutrition, and other essential services.

Together, these dimensions provide a comprehensive measure of development that extends beyond economic output and captures broader aspects of human welfare.

Maritime Shipping Operations and Human Development

The relationship between maritime shipping operations and human development can be explained through several interconnected channels.

First, shipping operations facilitate international trade and economic growth, which increase employment opportunities and household incomes. Higher incomes improve access to education, healthcare, housing, and other necessities that enhance quality of life.

Second, maritime activities generate government revenue through taxes, customs duties, shipping fees, and

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export earnings. These resources enable governments to invest in public services and infrastructure that improve human welfare.

Third, shipping operations stimulate industrial growth and investment by ensuring the efficient movement of raw materials, machinery, energy resources, and finished products. Industrial expansion creates jobs, promotes innovation, and enhances economic opportunities.

Finally, efficient shipping systems improve access to essential goods and services, including food products, medical supplies, educational materials, and industrial inputs. These benefits contribute directly and indirectly to improvements in human development outcomes.

Consequently, maritime shipping operations are increasingly recognized not only as drivers of economic growth but also as important contributors to sustainable human development.

2.3 Theoretical Perspectives

This study is anchored on Human Capital Theory and supported by Transport-Led Development Theory and Growth Pole Theory. These theories explain how maritime shipping operations contribute to human development through employment generation, income creation, trade facilitation, and industrial growth.

Human Capital Theory

The Human Capital Theory, developed by Schultz (1961) and Becker (1964), posits that productive economic activities generate resources that improve education, healthcare, skills acquisition, and living standards. The theory argues that investments in human welfare enhance productivity and sustainable development.

In the context of this study, maritime shipping operations generate employment opportunities, government revenue, foreign exchange earnings, and investment flows that support improvements in health, education, and income. Consequently, shipping activities are expected to positively influence Human Development Index (HDI).

Shipping Operations → Income & Employment → Human Capital Formation → Human Development

Transport-Led Development Theory

Transport-Led Development Theory maintains that efficient transportation systems stimulate economic growth by reducing transaction costs, improving market access, and promoting trade and investment.

Maritime shipping enhances connectivity, facilitates international trade, supports industrial production, and creates economic opportunities that contribute to improved welfare and living standards.

Efficient Shipping → Trade Expansion → Economic Growth → Human Development

Growth Pole Theory

Growth Pole Theory, advanced by Perroux (1955), argues that development is driven by strategic sectors with strong linkages to other sectors of the economy.

The maritime sector serves as a growth pole by supporting agriculture, manufacturing, construction, energy, and trade. Through these linkages, shipping operations stimulate employment, investment, and productivity, thereby contributing to human development.

Maritime Sector Growth → Industrial Expansion → Income Generation → Human Development

Theoretical Justification

While all three theories provide useful insights, Human Capital Theory serves as the principal framework because it directly explains how economic benefits generated by maritime shipping operations translate into

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improvements in health, education, income, and overall welfare.

The study therefore posits that Container Shipping Operations (CSO), Bulk Cargo Shipping Operations (BCSO), Tanker Shipping Operations (TSO), and Liquid Cargo Shipping Operations (LCSO) positively influence human development, while Infrastructure Development (IND) strengthens these relationships by enhancing the efficiency and effectiveness of maritime activities.

3. THEORETICAL FRAMEWORK

Human Capital Theory

This study is anchored on the Human Capital Theory developed by Schultz (1961) and further advanced by Becker (1964). The theory argues that economic activities generate resources that can be invested in education, healthcare, skills development, and other welfare-enhancing initiatives that improve human capabilities and quality of life. It emphasizes that sustainable development is achieved not only through economic growth but also through investments that enhance people's productivity, knowledge, and well-being.

The theory is particularly relevant to this study because maritime shipping operations constitute a productive sector that stimulates economic activities and creates opportunities for human advancement. Through trade facilitation and efficient movement of goods, shipping operations generate employment, increase household incomes, stimulate industrial production, attract domestic and foreign investments, and enhance government revenue. These outcomes provide the financial resources required for investments in education, healthcare, infrastructure, and social services, which are key components of human development.

In the Nigerian context, container shipping supports trade and commercial activities; bulk cargo shipping facilitates agriculture, manufacturing, and construction; tanker shipping generates export earnings and public revenue through petroleum exports; while liquid cargo shipping promotes energy security, industrialization, and economic diversification. Collectively, these activities contribute to income generation, job creation, and improved living standards, thereby enhancing human development outcomes.

Furthermore, the benefits of shipping operations are amplified when supported by efficient infrastructure such as ports, transport networks, logistics facilities, and digital maritime systems. Infrastructure development improves operational efficiency, reduces logistics costs, enhances connectivity, and increases the capacity of shipping activities to generate socio-economic benefits.

Consequently, Human Capital Theory provides a suitable framework for explaining how maritime shipping operations contribute to improvements in the core dimensions of the Human Development Index (HDI), namely:

- Health through increased public and private investment in healthcare services.
- Education through enhanced access to learning opportunities and human capital development.
- Income through employment creation, entrepreneurship, and economic expansion.

The theory therefore supports the proposition that maritime shipping operations, strengthened by infrastructure development, serve as important drivers of human development by transforming economic opportunities into improved welfare, enhanced capabilities, and better living standards.

4. METHODOLOGY

Research Design

This study adopts an ex-post facto research design and utilizes annual time-series data covering the period 1990–2025. The design is appropriate because it examines historical relationships among variables that are

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beyond the control of the researcher. It enables an assessment of how changes in maritime shipping operations have influenced human development in Nigeria over time.

Model Specification

The study models human development as a function of maritime shipping operations and infrastructure development:

$$HDI = f(C, S, O, B, CSOTSOLCSOIND)$$

The econometric model is specified as:

$$HDI_t = \beta_0 + \beta_1 CSO_t + \beta_2 BCSO_t + \beta_3 TSO_t + \beta_4 LCSO_t + \beta_5 IND_t + \varepsilon_t$$

To examine the moderating effect of infrastructure development, interaction terms between infrastructure development and the various shipping operation indicators are incorporated into the ARDL framework.

Description of Variables

Variable	Description
HDI	Human Development Index
CSO	Container Shipping Operations
BCSO	Bulk Cargo Shipping Operations
TSO	Tanker Shipping Operations
LCSO	Liquid Cargo Shipping Operations
IND	Infrastructure Development

Estimation Technique

The study employs the Autoregressive Distributed Lag (ARDL) approach due to its suitability for variables integrated at mixed orders, I(0) and I(1), and its ability to estimate both short-run and long-run relationships within a single framework.

The analytical procedure consists of:

- Unit Root Tests to determine the order of integration of the variables.
- ARDL Bounds Cointegration Test to establish the existence of a long-run equilibrium relationship.
- Long-Run Estimation to assess the sustained effects of shipping operations on human development.
- Error Correction Model (ECM) to capture short-run dynamics and the speed of adjustment to equilibrium.
- Diagnostic and Stability Tests to evaluate model reliability, including serial correlation, heteroscedasticity, normality, and parameter stability tests.

The ARDL framework provides a robust basis for assessing how container, bulk cargo, tanker, and liquid cargo shipping operations contribute to human development and how infrastructure development strengthens these relationships in Nigeria.

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5. RESULTS AND ANALYSIS

Cointegration Results

The ARDL Bounds Test confirms the existence of a long-run equilibrium relationship between maritime shipping operations and human development in Nigeria. This result indicates that changes in shipping activities and infrastructure development have sustained effects on human development over time and move together in the long run.

Long-Run Effects of Shipping Operations on Human Development

Variable	Coefficient	P-value
CSO	0.006996	0.0287
BCSO	0.055806	0.0000
TSO	0.005763	0.0003
LCSO	0.031939	0.0020

The long-run estimates reveal that all categories of maritime shipping operations exert positive and statistically significant effects on Human Development Index (HDI). Specifically, a rise in container, bulk cargo, tanker, and liquid cargo shipping activities contributes to improvements in health, education, and income outcomes.

Among the shipping indicators, Bulk Cargo Shipping Operations (BCSO) exert the strongest influence on human development, reflecting their critical role in supporting agriculture, manufacturing, construction, and industrial production. Liquid Cargo Shipping Operations (LCSO) also demonstrate a substantial contribution through energy supply, industrial growth, and export diversification, while container and tanker shipping activities support trade expansion, employment creation, and revenue generation.

Short-Run Effects of Shipping Operations on Human Development

Variable	Coefficient	P-value
CSO	0.004006	0.0240
BCSO	0.007766	0.0012
TSO	0.003476	0.0105
LCSO	0.006953	0.2110

The short-run results indicate that Container Shipping Operations (CSO), Bulk Cargo Shipping Operations (BCSO), and Tanker Shipping Operations (TSO) significantly improve human development in the immediate period. These findings suggest that increased trade activities, industrial production, and petroleum exports generate short-term benefits through employment, income growth, and economic opportunities.

Although Liquid Cargo Shipping Operations (LCSO) exhibit a positive coefficient, the effect is statistically insignificant in the short run, implying that the developmental benefits of liquid cargo transportation materialize gradually and become more evident over the long term.

Moderating Effect of Infrastructure Development

Interaction Term	Coefficient	P-value
CSO × IND	0.326395	0.0170
BCSO × IND	0.397664	0.0325
TSO × IND	0.091977	0.0349
LCSO × IND	0.090046	0.5349

The moderation analysis reveals that Infrastructure Development (IND) significantly strengthens the positive effects of container shipping, bulk cargo shipping, and tanker shipping on human development. The strongest moderating effect is observed in the relationship between Bulk Cargo Shipping Operations and Human

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Development, highlighting the importance of ports, transport corridors, logistics facilities, and cargo-handling infrastructure in enhancing the developmental benefits of productive economic sectors.

The positive interaction effects suggest that improvements in infrastructure increase shipping efficiency, reduce logistics costs, facilitate trade flows, and stimulate investment, thereby amplifying the contribution of maritime activities to welfare enhancement.

However, the interaction between liquid cargo shipping and infrastructure development is positive but statistically insignificant, indicating that infrastructure improvements alone may not be sufficient to strengthen the short-term developmental impact of liquid cargo operations.

Summary of Findings

Overall, the findings demonstrate that maritime shipping operations are important drivers of human development in Nigeria. While all shipping categories contribute positively in the long run, bulk cargo shipping emerges as the most influential determinant of human development. The results further confirm that infrastructure development serves as a critical catalyst, enhancing the ability of shipping operations to generate employment, income, industrial growth, and improved living standards. These findings underscore the strategic importance of sustained investments in maritime infrastructure as a pathway for achieving sustainable human development in Nigeria.

6. DISCUSSION OF FINDINGS

The findings demonstrate that maritime shipping operations play a significant role in promoting human development in Nigeria by enhancing trade, employment, income generation, industrial productivity, and investment opportunities. Both the short-run and long-run results indicate that improvements in shipping activities contribute positively to the Human Development Index (HDI), highlighting the strategic importance of the maritime sector in achieving sustainable development.

Among the shipping indicators, Bulk Cargo Shipping Operations (BCSO) emerged as the most influential determinant of human development. This finding reflects the sector's strong linkages with agriculture, manufacturing, construction, and infrastructure development. By facilitating the movement of essential raw materials and industrial inputs, bulk cargo shipping supports productive economic activities, stimulates employment, and improves household welfare.

Container Shipping Operations (CSO) were found to significantly enhance human development through improved trade efficiency, market access, and supply chain integration. Increased container traffic promotes commercial activities, attracts investment, creates employment opportunities, and raises income levels, which contribute to better living standards and improved social outcomes.

The positive effect of Tanker Shipping Operations (TSO) underscores the importance of Nigeria's petroleum export sector. Tanker shipping facilitates crude oil exports, generates foreign exchange earnings, and increases government revenue, thereby creating fiscal capacity for investments in education, healthcare, transportation, and other public services that support human development.

Similarly, Liquid Cargo Shipping Operations (LCSO) contribute to human development by promoting energy security, industrial expansion, and economic diversification. Although its short-run effect was insignificant, the long-run results suggest that the developmental benefits of liquid cargo transportation materialize gradually through increased industrial productivity and sustained economic growth.

The significant moderating effects of Infrastructure Development (IND) further emphasize that the developmental impact of maritime shipping depends largely on the availability of efficient ports, transport corridors, logistics facilities, and supporting maritime infrastructure. Improved infrastructure enhances

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operational efficiency, reduces logistics costs, facilitates trade flows, and strengthens the capacity of shipping activities to generate socio-economic benefits.

Overall, the findings support the Human Capital Theory, which posits that productive economic activities create resources and opportunities that improve education, healthcare, income, and overall welfare. The results therefore suggest that maritime shipping operations, when supported by adequate infrastructure, serve as a powerful mechanism for transforming economic growth into sustainable human development in Nigeria.

7. POLICY IMPLICATIONS

The findings of this study have important implications for maritime policy, infrastructure planning, and sustainable development in Nigeria. Since maritime shipping operations were found to significantly enhance human development, policymakers should adopt strategies that strengthen the efficiency, connectivity, and developmental impact of the maritime sector.

Modernization of Seaport Infrastructure

The positive relationship between shipping operations and human development highlights the need for continuous modernization of Nigeria's seaports. Investments should focus on upgrading port facilities, expanding terminal capacity, dredging navigation channels, and improving cargo-handling equipment. Modern and efficient ports will reduce vessel turnaround time, increase cargo throughput, lower logistics costs, and improve trade competitiveness. Enhanced port performance will further stimulate industrial growth, employment creation, and income generation, thereby supporting human development.

Expansion of Cargo-Handling Capacity

Given the significant contribution of bulk cargo shipping to human development, there is a need to expand cargo-handling facilities across major Nigerian ports. Additional storage facilities, bulk terminals, container yards, and specialized cargo equipment will improve operational efficiency and reduce congestion. Improved cargo capacity will enhance the movement of industrial inputs, agricultural commodities, and construction materials that support economic activities and welfare improvements.

Strengthening Multimodal Transport Connectivity

The study underscores the importance of integrating ports with road, rail, and inland transport systems. Efficient hinterland connectivity will facilitate faster cargo evacuation, reduce transportation costs, and improve market access. Government should prioritize the development of rail-port connections, rehabilitation of access roads, and expansion of inland logistics corridors to maximize the developmental benefits of maritime trade.

Digitalization of Maritime Logistics Systems

Digital transformation of port and logistics operations is essential for improving efficiency and transparency. The adoption of Port Community Systems (PCS), electronic customs clearance, cargo-tracking technologies, and automated terminal operations can significantly reduce delays and administrative bottlenecks. Digitalization will improve service delivery, enhance trade facilitation, and strengthen Nigeria's competitiveness within global supply chains.

Investment in Maritime Human Capital Development

The findings support the proposition that shipping operations contribute to human development through employment and income generation. Consequently, increased investment in maritime education, professional training, and skills development programmes is necessary. Government agencies, maritime institutions, and private sector stakeholders should strengthen training in shipping management, logistics, marine engineering,

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port operations, and digital maritime technologies to build a highly skilled workforce capable of supporting sectoral growth.

Promotion of Public-Private Partnerships (PPPs)

The scale of infrastructure investment required within the maritime sector necessitates stronger collaboration between government and private investors. Public-private partnerships should be encouraged in port development, logistics infrastructure, transport connectivity, and maritime technology projects. Such partnerships can accelerate infrastructure expansion, improve operational efficiency, and enhance service quality while reducing the fiscal burden on government.

Leveraging Maritime Transport for Human Development

The results suggest that maritime policies should move beyond traditional trade and revenue objectives to explicitly incorporate human development goals. Maritime sector investments should be designed to promote employment creation, poverty reduction, income growth, skills acquisition, and improved access to social services. This will ensure that gains from shipping activities translate into tangible improvements in education, healthcare, and overall quality of life.

Infrastructure Development as a Strategic Priority

The significant moderating effect of infrastructure development indicates that the developmental impact of shipping operations is amplified when supported by efficient infrastructure. Therefore, policymakers should prioritize investments in ports, transport corridors, logistics facilities, warehousing systems, and digital infrastructure. Strengthening these systems will improve shipping efficiency, expand economic opportunities, and maximize the contribution of maritime transportation to sustainable human development.

Policy Summary

To maximize the contribution of maritime shipping operations to human development in Nigeria, policy efforts should focus on:

- Modernizing and expanding port infrastructure.
- Increasing cargo-handling and storage capacity.
- Enhancing rail, road, and inland transport connectivity.
- Accelerating digitalization of maritime logistics systems.
- Strengthening maritime education and workforce development.
- Promoting public-private partnerships in maritime infrastructure.
- Aligning maritime policies with human development objectives.
- Prioritizing infrastructure investments that support trade, productivity, and welfare improvement.

Collectively, these measures will strengthen the efficiency and competitiveness of Nigeria's maritime sector while enhancing its capacity to generate employment, attract investment, stimulate industrial growth, and improve human development outcomes.

8. CONCLUSION

This study examined the relationship between maritime shipping operations and human development in Nigeria, with particular emphasis on the moderating role of infrastructure development over the period 1990–2025. The study contributes to the growing maritime economics and development literature by moving beyond conventional measures of economic performance and focusing on human development as reflected in the Human Development Index (HDI).

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The empirical findings provide strong evidence that maritime shipping operations constitute an important driver of human development in Nigeria. The ARDL results revealed that Container Shipping Operations (CSO), Bulk Cargo Shipping Operations (BCSO), Tanker Shipping Operations (TSO), and Liquid Cargo Shipping Operations (LCSO) exert positive long-run effects on human development. These findings suggest that maritime activities contribute significantly to improvements in income, living standards, employment opportunities, and the broader socio-economic conditions necessary for human welfare.

Among the shipping categories examined, Bulk Cargo Shipping Operations emerged as the strongest contributor to human development. This reflects the strategic role of bulk transportation in supporting agriculture, manufacturing, mining, construction, and infrastructure development, all of which are critical sectors for job creation, poverty reduction, and sustainable economic transformation. The findings further indicate that container shipping enhances trade efficiency and market accessibility, tanker shipping generates foreign exchange earnings and public revenue, while liquid cargo shipping promotes energy security, industrial expansion, and economic diversification.

A key contribution of the study is the demonstration that Infrastructure Development (IND) significantly strengthens the developmental impact of maritime shipping operations. The positive interaction effects indicate that efficient ports, logistics facilities, transport corridors, warehousing systems, and supporting infrastructure enhance the capacity of shipping activities to generate socio-economic benefits. Thus, infrastructure serves not merely as a supporting factor but as a strategic catalyst that transforms maritime activities into tangible improvements in human welfare.

The findings also provide empirical support for the Human Capital Theory, which posits that productive economic activities generate resources that can be invested in education, healthcare, skills acquisition, and welfare enhancement. The results confirm that maritime shipping operations support human development through employment creation, income generation, industrial growth, investment attraction, and government revenue mobilization. These outcomes contribute directly and indirectly to the three core dimensions of human development: health, education, and income.

From a policy perspective, the study establishes that maritime development should not be viewed solely through the lens of trade promotion and revenue generation. Rather, maritime shipping operations should be strategically leveraged as instruments for achieving broader development goals, including poverty reduction, employment generation, human capital development, and improved living standards. Investments in maritime infrastructure, logistics modernization, digital port systems, multimodal transport networks, and workforce development are therefore essential for maximizing the contribution of the maritime sector to national development.

Overall, the study concludes that a well-developed and efficiently managed maritime sector has the potential to serve as a powerful engine for sustainable human development in Nigeria. By strengthening shipping operations and investing in complementary infrastructure, policymakers can unlock greater developmental benefits from the maritime sector and enhance the quality of life of the Nigerian population. Future studies may extend this analysis by examining the effects of maritime shipping operations on specific dimensions of human development such as poverty reduction, employment, income inequality, and social inclusion.

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Data Availability Statement

The data utilized in this study were obtained from recognized maritime and development institutions, including the Nigerian Ports Authority (NPA), Nigerian Maritime Administration and Safety Agency (NIMASA), World Bank, United Nations Development Programme (UNDP), and related sources. Data are available from the corresponding author upon reasonable request.

Conflict of Interest

The author declares no conflict of interest.

Contribution to Knowledge

This study contributes to existing literature in four important ways:

1. It extends maritime transport research beyond traditional economic growth indicators by employing the Human Development Index (HDI) as a measure of development.

2. It provides a disaggregated analysis of shipping operations by examining the distinct effects of container shipping, bulk cargo shipping, tanker shipping, and liquid cargo shipping on human development.

3. It introduces Infrastructure Development as a moderating variable, thereby revealing how infrastructure enhances the developmental impact of maritime activities.

4. It provides robust evidence on both short-run and long-run relationships using the ARDL framework, offering valuable insights for maritime policy and sustainable development planning.

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