Harnessing Alternative Transportation System for Efficient Food Supply Chain in Nigeria: Role of the Blue Economy

Mgbomene, Chukunalu

Department of Economics, Delta State University, Abraka
Email: chukunalum@delsu.edu.ng

Abstract

This research focused on harnessing the alternative transportation system for efficient food supply chain in Nigeria with emphasis on the blue economy. There has been less attention to the role offered by alternative transportation system within the blue economy on food supply chain efficiency in Nigeria. The study gathered data on maritime transport output, government investment in port infrastructure, shipping technology, employment in maritime transport as the independent variables while food supply chain efficiency (proxied with agricultural yield that reaches the final consumer) as the dependent variable. The data were analyzed using the error correction model. The result revealed that maritime transport output and port infrastructure negatively affected food supply chain efficiency in Nigeria, shipping technology positively affected food supply chain efficiency but not significantly while employment in maritime transport positively affected food supply chain efficiency significantly. The study concluded that Nigeria has not fully explored the opportunities provided by the blue economy in ensuring food supply efficiency and part of the recommendations was the increase in government investment towards the construction, repair and renovation of port infrastructure across the country. As the Nigerian government leverages on public-private partnership to improve maritime transportation, government should realize that it has a higher stake towards ensuring continued development of port infrastructure as this will ensure smooth delivery of fresh food products into Nigeria and smoothen food supply chain efficiency across Nigeria.

Keywords: Alternative transportation system, blue economy, maritime transport output, port infrastructure & shipping technology.

Introduction

The global food supply chain is crucial for maintaining food security, although it encounters increasing challenges stemming from inefficiencies in transportation networks. These inefficiencies result in elevated operational expenses, delays, spoilage, and eventually, food insecurity in multiple regions. In underdeveloped nations, these issues are more acute due to inadequate infrastructure and dependence on antiquated terrestrial transportation systems. Coastal and island nations are particularly susceptible to disruptions in their food supply chains, as conventional transport routes fail to meet the demands of a growing population and the challenges of urbanization (Rouf *et al*., 2019; Bari, 2017).

A promising answer to these difficulties is to leverage alternative transportation systems within the blue economy framework. The blue economy denotes the sustainable utilization of oceanic resources to foster economic development, enhance livelihoods, and promote marine ecosystem vitality. Maritime transport, a crucial element of the blue economy, provides a more economical, environmentally sustainable, and efficient alternative to terrestrial transport. Considering that oceans encompass more than 70% of the earth's surface, the incorporation of maritime transportation systems into food supply chains offers a substantial opportunity to decrease logistical expenses, enhance food distribution, and advance global sustainability objectives (Tigchelaar *et al*, 2022; Choudhary *et al*, 2021). The blue economy has been extensively examined concerning industries like fisheries, tourism, and coastal development, although its contribution to enhancing food supply chain efficiency remains insufficiently investigated. Maritime transport, typically less carbon-intensive than land or air alternatives, could markedly improve food logistics by offering expedited and more efficient distribution routes, especially in areas with inadequate or unreliable road infrastructure (Heydari, 2024; Bennett *et al*., 2024).

Notwithstanding the clear benefits, the implementation of blue economy principles in food logistics encounters numerous obstacles in coastal communities, including insufficient coastal infrastructure, restricted investment in maritime technologies, and deficient policy frameworks (Rouf *et al.*, 2019). The increasing interest in incorporating maritime transport into food supply chains is propelled by the pressing necessity for sustainability in global food systems. Heightened dependence on sustainable and economical transportation technologies is seen essential for reducing the environmental effects of food logistics and tackling climate change (Bennett *et al*., 2024). Maritime transport possesses a reduced carbon footprint relative to road and air transport, rendering it a crucial element of sustainable food systems under climate uncertainties (Pane *et al.*, 2021). Consequently, investigating the optimization of the blue economy to improve food supply chains may yield essential remedies for the inefficiencies and environmental issues linked to conventional transportation networks.

Nevertheless, the use of alternative maritime transportation technologies into food logistics presents some obstacles. This encompasses challenges associated with infrastructure development, technical innovation, policy execution, and the financial sustainability of maritime logistics systems (Choudhary et al., 2021). In numerous developing nations, where infrastructure is either inadequate or badly maintained, implementing maritime solutions for food distribution may appear challenging. Furthermore, the expense associated with enhancing ports and maritime technologies for food distribution presents a considerable obstacle. Notwithstanding these hurdles, the prospective advantages of a blue economy-driven food supply chain—augmented food security, reduced transportation expenses, and improved sustainability—render this a vital domain for research and development (Heydari, 2024; Tigchelaar *et al*., 2022).

Consequently, this study seeks to investigate how alternative transportation, in relation to the blue economy, might be utilized to enhance the efficiency of food supply chains in Nigeria. This study analyzes the capacity of maritime transport to mitigate inefficiencies, decrease expenses, and enhance sustainability in food logistics. The specific objectives of the study include to;

i. analyze the extent to which maritime transport output contributes to food supply chain efficiency in Nigeria;
ii. investigate the effect of government investment in port infrastructure on food supply chain efficiency in Nigeria;
iii. determine the relationship between shipping technology and food supply chain efficiency in Nigeria; and
iv. ascertain the extent to which employment in maritime transport industry affects food supply chain efficiency in Nigeria.

This study evaluates the role of the blue economy in promoting the transition to more sustainable and efficient food supply chain in Nigeria. This will facilitate a more profound comprehension of how maritime transit may augment and improve current food distribution networks. This study's findings are anticipated to provide significant insights for policy makers, businesses, and international organizations aiming to improve food supply while reducing the environmental and cost impact of food transportation. The pertinent research questions include:

i. To what extent has maritime transport output contributed to food supply chain efficiency in Nigeria?

ii. What effect does government investment in port infrastructure have on food supply chain efficiency in Nigeria?

iii. What is the relationship between shipping technology and food supply chain efficiency in Nigeria?

iv. To what extent has employment in maritime transport industry affected food supply chain efficiency in Nigeria?

These research questions are transformed into research hypotheses for the purpose of empirically proving the relationship between the variables. The hypotheses assumes no significant relationship between maritime transport output, government investment in port infrastructure, shipping technology, employment in maritime transport and food supply chain efficiency in Nigeria.

Review of Related Literature

This section reviews the conceptual frameworks, relevant theories, and empirical studies related to the integration of alternative transportation systems, particularly within the blue economy, to improve food supply chain efficiency. The purpose of this review is to provide a comprehensive understanding of how maritime transport, as an integral part of the blue economy, can enhance food security and economic growth, particularly in developing economies where traditional transportation systems face significant challenges.

Conceptual Clarification

Blue Economy

The blue economy is defined as the sustainable use of ocean resources for economic growth, improved livelihoods, and ecosystem health (World Bank, 2017). It encompasses a range of industries, including shipping, fisheries, and coastal tourism, all of which rely on the health of marine ecosystems. According to Martinez-Vázquez and Milán-García (2021), the blue economy offers significant potential for economic growth through sustainable maritime industries. A central aspect of this is maritime transport, which offers several advantages over land-based transportation systems, including reduced carbon emissions, lower operational costs, and more reliable transportation routes, especially in coastal and island economies where road infrastructure may be insufficient (Bennett *et al.*, 2024).

The role of maritime transport in logistics is increasingly recognized for its ability to address inefficiencies in global supply chains. In many regions, particularly in developing economies, road infrastructure is unable to handle the growing demand for food products. Maritime transport, a central component of the blue economy, presents a sustainable and cost-effective solution. Studies suggest that the adoption of maritime transportation can significantly enhance the efficiency of food supply chains by offering faster, more reliable, and environmentally friendly transportation options (Tigchelaar *et al.*, 2022; Rouf *et al*., 2019).

Alternative Transportation Systems

Alternative transportation systems, specifically maritime transport, are seen as key solutions to the inefficiencies of traditional land-based food logistics. In developing regions, where road transport is either underdeveloped or overburdened, maritime routes offer a viable alternative (Pane et al., 2021). Maritime transportation is not only more sustainable, due to its lower environmental impact, but it also provides greater efficiency in the movement of goods. This is particularly important for food supply chains, where timeliness and cost efficiency are critical in reducing waste and ensuring food security (Bari, 2017).

Liner Shipping Connectivity Index

Maritime transport technology development is measured by Liner Shipping Connectivity Index (LSCI). The LSCI captures how well countries are connected to global shipping networks and considered an alternative measure of openness to global food and commodity trade (World Bank, 2023). LSCI is computed based on five major components of connectivity: maximum vessel size, the total container-carrying capacity of ships, number of ships, number of companies that deploy container ships on services from and to a country's ports, and number of services. A country with high connectivity index could easily access a high capacity and frequency global maritime transport system, making effective participation of such a country easier in global food and commodity trade. Between 2005 and 2021, Nigeria's LSCI values averaged 20.97. The 2005 LSCI for Nigeria was 13.02 it reached 20.77 in 2021. As at end of 2023, Nigeria recorded an LSCI value of 21.71 (World Bank, 2023).

Food Supply Chains

Food supply chains involve the entire process of food production, processing, and distribution, from farm to table. The efficiency of these chains is critical in ensuring food security. Bari (2017) explains that the inefficiency of food supply chains, particularly in developing nations, is often due to logistical barriers such as high transportation costs, inadequate infrastructure, and political instability. Improving food logistics through alternative transportation methods, such as maritime transport, offers a promising solution to these challenges. This integration not only addresses food security concerns but also provides a more sustainable way of transporting food, contributing to the overall resilience of global food systems (Mgbomene, 2024b; Tigchelaar *et al*., 2022). In this research, agricultural yield that gets to the final consumers is used as proxy for efficient food supply chain. Mgbomene (2024a) argues that the agricultural sector provides the needed raw materials for every other sector of the economy. Thus, ensuring smooth delivery of agricultural products to the end consumer is the function of the food supply chain.

Theoretical Framework

Understanding the relationship between economic growth, transportation, and logistics is essential for analyzing the role of alternative transportation systems in food supply chains. Several theoretical frameworks are particularly relevant.

Theories of Economic Growth: The Neo-Classical Growth Theory, developed by Robert Solow (1956) posits that economic growth is driven by increases in capital, labor, and technology. For economies to sustain growth, investments in infrastructure, including transportation systems, are crucial. In the case of food supply chains, the development of alternative transport systems, such as maritime transport, plays a significant role in reducing costs and improving logistics, which in turn promotes economic growth (Solow, 1956). The Harrod-Domar Growth Model (Harrod, 1939 & Domar, 1946) emphasizes the importance of savings and investment in stimulating economic growth. In developing economies, investment in transportation infrastructure is vital for boosting economic productivity and promoting development (Mgbomene, 2024b). According to this model, investing in maritime transport can enhance food distribution, reduce waste, and ultimately drive economic growth by improving the efficiency of supply chains (Ahuja, 2010).

The theory of sustainable development as outlined by the United Nations (UN, 2000) aligns closely with the principles of the blue economy. It asserts that economic growth should occur without compromising the ability of future generations to meet their needs. The blue economy, through sustainable practices in maritime transport, offers a way to achieve this goal by reducing the carbon footprint of food logistics and improving the efficiency of food supply chains. Choudhary *et al* (2021) emphasizes that the blue economy's focus on sustainability and environmental stewardship is essential for addressing the challenges posed by climate change, particularly in food distribution systems. Thus, leveraging on government investment in maritime transportation coupled with the sustainable development ideology, there is an expected growth in efficiency of food supply chain and this theory is subjected to empirical verifications in the latter part of this research.

Review of Empirical Literature

A growing body of empirical research has examined the role of alternative transportation such as the one offered by the blue economy in improving food supply chain efficiency, particularly in developing and coastal regions. **Tigchelaar *et al* (2022)** conducted a study that examined the role of sustainable maritime transportation in food logistics. The study found that adopting **eco-friendly vessels** and **maritime transport systems** significantly reduced food logistics costs, especially in regions where road infrastructure was insufficient. Their research highlights that improving the efficiency of maritime transport not only accelerates food distribution but also reduces spoilage and waste, which is critical for ensuring food security in developing nations.

Similarly, **Bennett *et al* (2024)** explored the financial and environmental benefits of integrating **maritime transport** into food logistics. Their study concluded that alternative transportation systems within the blue economy could reduce transportation costs by as much as 30% in certain coastal regions, leading to faster delivery of food to urban centers. This contributes to reduced food spoilage, lower costs, and improved access to fresh produce, all of which enhance food security in these regions.

A study by **Rouf et al (2019)** focused on the challenges faced by developing countries in adopting blue economy principles in food logistics. The study found that while maritime transport offers clear advantages, the high initial costs of infrastructure development and the limited availability of modern maritime technologies hindered the widespread adoption of these systems. The researchers recommended increased investment in port infrastructure and policy reforms to encourage the integration of maritime transport into food supply chains.

Pane *et al* (2021) examined how the blue economy can promote sustainable economic growth in island nations through improvements in maritime transport infrastructure. Their study argued that investing in **eco-friendly vessels** and expanding port facilities would reduce dependence on costly land-based transport, enhance food distribution efficiency, and contribute to long-term economic growth. In another related study, **Martinez-Vázquez and Milán-García (2021)** highlighted the potential of maritime transport to mitigate the challenges posed by climate change. They found that sustainable shipping routes and improved port infrastructure could significantly reduce the carbon footprint of food logistics, ultimately enhancing food security while supporting sustainability goals.

Onwude *et al* (2023) examined bottlenecks in Nigeria's fresh food supply chain. The study adopted the literature review method and found that a key bottleneck is that most fresh food produced in the northern region is largely consumed in the south, with the produce traveling long distances through a poor road network. According to the researchers, the lack of a continuous cold chain is another key causative factor for food loss; less than 10% of the fresh food produced passes through a cold chain despite the long distances it needs to travel. There is also limited access to supply chain data and expert market intelligence to assist stakeholders in the decision-making process and process optimizations. They suggested that smallholder farmers would significantly benefit from easier access to expert intelligence on postharvest storage and market information.

Emenyonu, Onyemechi, Nze and Ndikom (2024) evaluate maritime security and blue economy development in Nigeria using structural equation modeling. Data used include crews kidnapped for ransom, crude oil theft, employment in maritime transport, military security expenditure, marine insurance premium, GDP from maritime transport and GDP from fishing sector. The findings of the study revealed that 56 % of maritime security threats in Nigeria waters can be predicted by the number of crewmen kidnapped for ransom, 55 % by pirates' attacks, and 92 % by crude oil theft in Nigerian waters. Similarly, the results revealed that maritime security threats have a significant effect on blue economy development in Nigeria.

Panigrahi and Singh (2024) researched on robust food supply chains in SMEs by exploring and analyzing the literature through the lenses of digital technologies. The study collected data from Scopus spanning from 2010 to 2024, employing selected keywords, and processed it using VOS-viewer and Biblioshiny to derive valid inferences and theoretical arguments. They identified several key themes shaping the future of supply chain management – Sustainability in supply chain management, industry 4.0, digitalization, circular economy, food waste with supply chain, food security and climate change. These themes collectively bring transformative opportunities for both the adoption of digital technologies in easing food transportation and sustainable practices in food supply chains.

Osuji and Agbakwuru (2024) examined ten important blue economic components and evaluated their contributions to the sustainable development of Nigeria using various secondary data acquisition. Data obtained revealed that out of the ten (10) blue economic components studied, oil/gas exploration, maritime transport/shipping and fisheries dominate the blue economic contributions with the oil/gas exploration contributing 90% of the blue economic value in Nigeria. They advocated for more efforts from both government and private sectors to pursue the huge opportunities available especially in the non-oil/gas exploration components to sustainably improve the economic base of the nation and generate huge employment opportunities for the large growing Nigerian population. Ibeaja, Amadi and Dim (2022) found that government intervention in agricultural sector by way of investments and credit propels growth of agricultural production. Investing in alternative transportation means further growth in agricultural production and food supply.

Agbakwuru and Osuji (2024) provided relevant information on the economic analysis of the potential offshore aquaculture practice to enhance the diversification of the blue economy in Nigeria using secondary data. Ten (10) fish cages of 37500-fish capacity per cage were hypothetically designed with fiberglass materials and installed in Escravos offshore. A mortality of 30% was used with the current prices of other required investments. The analysis recorded a breakeven period of 2 years and NPV value of over one trillion Naira in 9 years indicating massive profitability comparable to the oil and gas industry. Sensitivity analysis identified mortality/loss of fish and falling prices of fish as events that could adversely affect the investment. This research is relevant to this study because it shows alternative means of generation of investments from the blue economy which ensures sustainable food supply in Nigeria.
Evidently, studies linking blue economy as an alternative transportation system for efficient food supply chain have been reviewed but there appears to be a missing piece. The missing link is the adoption of time series econometric technique in ascertaining the role of blue economy in ensuring efficient food supply chain. While Rouf et al. (2019), Bennett et al. (2024), Tigchelaar et al. (2022), Martinez-Vázquez and Milán-García (2021) explored various aspects of the impact of blue economy on food logistics, their studies did not provide the needed footprint to replicate same for Nigeria since there was no forecast technique used. Again, the studies on the Nigerian economy (Onwude *et al*, 2023, Emenyonu, Onyemechi, Nze and Ndikom, 2024, Osuji & Agbakwuru, 2024) did not incorporate government investment in port infrastructure, shipping technology and employment in maritime transport as variables of blue economy. The importance of blue economy in ensuring sustainable and efficient food supply chain is explained by the interactions of these variables in the time series econometric model.

Research Methodology

This study adopts a quasi-experimental research design to analyze the impact of blue economy in providing alternative transportation means for efficiency of food supply chain in Nigeria. According to Nworgu (2006), quasi-experimental design is suitable for studies using secondary data, as it allows researchers to establish a potential linear relationship between dependent and independent variables. This study utilizes secondary data to assess how advancements in maritime transport and infrastructure impact food logistics, particularly in Nigeria. The data for the independent and dependent variables are sourced from reputable national and international databases.

Model Specification

The model specification expresses the mathematical and economic relationships between the dependent variable (food supply chain efficiency) and the selected independent variables (maritime transport, port infrastructure, maritime technology, and employment in maritime transport). This study builds on previous research on the relationship between infrastructure and logistics efficiency, such as studies by Bennett *et al* (2024) and Tigchelaar *et al* (2022), which focus on the effects of maritime transport systems on trade efficiency. In previous research on infrastructure and logistics, similar models have used economic performance indicators like maritime infrastructure and how they affect output growth (GDP) like in the study of Emenyonu *et al* (2024). In this study, however, the focus is specifically on maritime transport, port infrastructure, maritime technology, and government investment, which are expected to be key drivers of food supply chain efficiency.

The study modifies the traditional **neo-classical growth theory of Solow (1956)** by linking the growth drivers to blue economy variables as well as modify the model of Emenyonu *et al* (2024) by incorporating a dynamic approach that examines the short-run and long-run effects of the selected variables on food supply chain efficiency. The model is specified as follows:

$$AGR = f(MT, PI, ST, EP) \quad [i]$$

Where:

AGR = Agricultural yield that reaches the final consumers (proxy for food supply chain efficiency)

MT = Maritime transport contribution to GDP

PI = Government investment in port infrastructure

ST = Shipping Technology (Liner Shipping Connectivity Index)

EP = Employment in maritime transport industry

The econometric form of the model becomes:

$$FSC = \alpha_0 + \beta_1 MT + \beta_2 PI + \beta_3 ST + \beta_4 EP + \mu_t \quad [ii]$$

Where α_0 is the intercept of the model, β_1-β_4 represents the unknown coefficients of the model to be estimated. The study adopts the first-differenced data to examine the changes in the variables over time and to avoid potential issues of spurious regression.

Sources of Data

Data for this study are sourced from reputable secondary data sources. These sources provide historical data on the variables selected for the analysis. The following are the primary sources of data:

i. **Central Bank of Nigeria (CBN) Statistical Bulletin:** Provides data on agricultural yield to end consumers, maritime transport annual output, port infrastructure investments by the government, and related economic indicators, which is used to track changes in the maritime transport system. Data is available on www.cbn.gov.ng

ii. **World Bank Database:** Offers comparative data on maritime transport employment rate, and Liner Shipping Connectivity Index, useful for benchmarking Nigerian maritime industry against international standards. It is available on www.data.worldbank.org/

iii. **International Maritime Organization (IMO):** Supplies global maritime transport data, including port infrastructure development trends. This data source is used to augment missing years from the CBN data.

Data Analysis Techniques

The data is analyzed using error correction model econometric technique. It is primarily Ordinary Least Squares (OLS) regression used in estimating the relationships between the dependent and set of independent variables while taking cognizance of the level of stationarity of the data. First-differenced data is employed to ensure stationarity and to capture the short-term changes in each variable while avoiding spurious regression results. The Error Correction Model (ECM) is applied to examine the short-term dynamics and long-term equilibrium relationships between agricultural yield, maritime transport output, port infrastructure, shipping technology, and employment in maritime transport. Diagnostic tests, including the Augmented Dickey-Fuller (ADF) test for stationarity, Johansen Cointegration test, and Granger Causality tests, is conducted to ensure the validity and robustness of the model.

Results of the Findings

The data analysis starts with the test for stationarity on each of the variables. This is necessary in order to ensure that the data have time series properties and can be used in forecasting. The stationarity test is followed by the cointegration test which ascertains the long run relationship between the variables. The granger causality test tests for the possibility of a one or two directional relationship between the variables prior to the error correction model estimation.

Table 1: Stationarity Test

Variable	ADF @Level	ADF @First Diff.	Order of Integration
Agric Supply to End Consumer	-2.0039 [0.5778]	-4.4143* [0.0071]	Stationary at First Difference
Maritime Transport Output	-2.6300 [0.2705]	-5.9462* [0.0001]	Stationary at First Difference
Port Infrastructure	0.8292 [0.9996]	-5.0519* [0.0015]	Stationary at First Difference
Shipping Technology	-1.9292 [0.6169]	-3.6445* [0.0421]	Stationary at First Difference
Employment	-1.5828 [0.2370]	-9.7640* [0.0000]	Stationary at First Difference

Source: Result Extracted from Eviews Output

Table 2: Long run Cointegration Test

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.686627	70.70422	69.81889	0.0424
At most 1	0.384164	33.57263	47.85613	0.5253
At most 2	0.278973	18.05983	29.79707	0.5616
At most 3	0.203193	7.593331	15.49471	0.5099
At most 4	0.010097	0.324749	3.841466	0.5688

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.686627	37.13159	33.87687	0.0197
At most 1	0.384164	15.51279	27.58434	0.7067
At most 2	0.278973	10.46650	21.13162	0.7000
At most 3	0.203193	7.268582	14.26460	0.4579
At most 4	0.010097	0.324749	3.841466	0.5688

Source: Extracted from Eviews Output

Table 1 and table 2 above summarizes the stationarity and cointegration tests using the Augmented Dickey Fuller (ADF) unit root test and Johansen cointegration test respectively. The stationarity test reveals that all the variables are significant after first differencing which implies that they are stationary at first difference. The differencing of the data became necessary since the level data showed no integration (stationarity). Having found no stationarity at level, the first difference of the data was taken since the data are pre-supposed to be stationarity in order to be deemed suitable for the econometric forecast and analysis.

Having found that the data achieved stationarity at first difference, the cointegration test (Table 2) confirmed the long run relationship between the blue economy variables and food supply chain efficiency (proxied with agricultural products supplied to consumers). The basis for asserting the long run relationship was the probability value of the Trace and Max-eigen statistic which showed one significant *p-value* at 5% level. Hence, the existing of at least one cointegrating equation confirms the long run relationship between the variables.

Table 3: Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
MT does not Granger Cause AGR	**32**	**1.38266**	**0.2681**
AGR does not Granger Cause MT		**0.48173**	**0.6229**
PI does not Granger Cause AGR	**32**	**0.81096**	**0.4550**
AGR does not Granger Cause PI		**0.13492**	**0.8744**
ST does not Granger Cause AGR	**32**	**0.68692**	**0.5117**
AGR does not Granger Cause ST		**1.75450**	**0.1921**
EP does not Granger Cause AGR	**32**	**7.99159**	**0.0160**
AGR does not Granger Cause EP		**2.22208**	**0.1278**

Source: Extracted from Eviews Output

Evidence from Table 3 above shows that only employment in the maritime transport industry granger causes agricultural yield (food chain efficiency). There was no further causality found between the variables. Thus, the study asserts that the present trend of growth in maritime transport employment can be used to predict and forecast future growth in agricultural food chain efficiency in Nigeria.

Table 4: Error Correction Model

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.377310	0.194168	1.943219	0.0633
MT	-1.688302	0.362053	-4.663129	0.0001
PI	-0.000402	0.000151	-2.663039	0.0134
ST	0.020315	0.015959	1.272979	0.2147
EP	8.125625	0.794904	10.22214	0.0000
ECM(-1)	-0.300770	0.053463	-5.625760	0.0093
R-squared	**0.884851**	**F-statistic**		**32.50486**
Adjusted R-squared	**0.881821**	**Prob(F-statistic)**		**0.000000**
S.E. of regression	**0.197070**	**Durbin-Watson stat**		**1.916746**

Source: Extracted from Eviews Output

Table 4 above shows that maritime transport output (MT) decreases food supply chain efficiency by 1.688 units. The decrease was significant given the *p-value* of 0.001 < 0.05. Also, port infrastructure (PI) has a decreasing effect on food supply chain efficiency decreasing it significantly by 0.0004 units (*p-value = 0.0134 < 0.05*). There was positive effect of shipping technology (ST) and maritime industry employment (EP) on food supply chain efficiency with both variables increasing food supply chain by 0.0203 and 8.1256 units respectively. While the increase in food supply chain efficiency occasioned by shipping technology (ST) was not significant (*p-value = 0.2147>0.05*), maritime industry employment (EP) exerted significant increase on food supply chain efficiency (*p-value = 0.0000<0.05*).

Discussion of Findings

This research set out to achieve the specific objectives of determining the effect of maritime transport output, port infrastructure, shipping technology and maritime transport employment on food supply chain efficiency in Nigeria for the period 1990 through 2023. The data were analyzed using error correction model technique which incorporates the long run speed of adjustment of the independent variables on the dependent variable.

The result revealed that maritime transport output and port infrastructure both decreased food supply chain efficiency in Nigeria by 1.688 and 0.0004 units. The decrease in food supply chain efficiency was statistically significant which implies that maritime transport has not contributed expectedly to the development of agricultural products in Nigeria and that port infrastructure is still below expected level of development and has led to decreased supply of agricultural products to the end users in Nigeria. These two assertions corroborate the point made by Emenyonu et al (2024) that threats to maritime transportation has profound effect on the development of the blue economy in Nigeria. Also, Onwude *et al* (2023) asserted that postharvest storage is a problem for food supply in Nigeria with poor maritime transport network which has put nearly 90% of fresh food products at risk of not reaching the final consumer in every harvest period. Similarly, Rouf *et al* (2019) posited that high initial costs of infrastructure development and the limited availability of modern maritime technologies hindered the widespread movement of food products across developing countries.

The study of Osuji and Agbakwuru (2024) found contrary view that maritime transport/shipping dominate the blue economic contributions. However, their study was mostly tilted towards the effect of blue economy on sustainable development rather than on food supply chain efficiency in Nigeria. Also, **Tigchelaar *et al* (2022) found that maritime transport systems** significantly reduced food logistics costs but their research was in Indonesia which has different data when compared with Nigeria. With maritime transport output and port infrastructure accounting for negative trend in food supply efficiency in Nigeria, there is growing need for strategies that will set maritime transport on the path to sustaining Nigeria's food supply efficiency. This will be discussed in the next section of this research.

Further findings from this study revealed that shipping technology (proxied with LSCI, Liner Shipping Connectivity Index) and employment in the maritime transport industry both showed positive effects on food supply efficiency in Nigeria contributing 0.020 and 8.126 units to growth in agricultural products to end users. The implication of this is that the high capacity and frequency of the Nigerian maritime transport system (measured by shipping technology LSCI) has increased the efficiency of food supply chain but the increase was not significant given the intervening negative effects of maritime transport output and negative port infrastructure. Thus, the blue economy in Nigeria, especially, shipping technology is still not developed to global standards and for this reason the movement of agricultural products has not been as expected over the years. **Bennett *et al* (2024)** found that access to technology will help improve maritime transport efficiency hence improving access to fresh produce. Panigrahi and Singh (2024) found that adoption of digital technologies can ease food products transportation in developing countries. With employment in the maritime industry showing positive and significant strides, there is need to look towards the development of this means transportation in Nigeria.

Conclusion

There is increased advocacy for alternative transportation systems globally. Nigeria has a thriving market for food products and what remains is the efficient distribution of food products from the point of production/harvest to the point of consumption. This function is what the blue economy offers as it provides an efficient and eco-friendly means f transportation that involves large goods carriage from one point to another. This study has explored variables linking blue economy to Nigeria's food supply chain and has come to the conclusion that maritime transportation in Nigeria has remained on the back foot in its contribution to overall GDP growth and this has spelled negative effect on food supply chain efficiency in the country. Port infrastructure is still underdeveloped with low investments and this has led to low shipping technology which despite the positive effect it exerts on food supply chain it still has not significantly enhanced food supply chain efficiency. With growing employment in the maritime industry in Nigeria, the blue economy is still not developed optimally to propel efficiency in food supply chain in Nigeria.

Recommendations

Based on the findings of the study, the following recommendations are made;

i. Government should engage in massive and urgent investment in alternative transport means such as the one offered by the Blue economy owing to the fact that maritime transport means had no boosting effect on agricultural yield from the finding. This will enhance efficiency in agricultural productivity and the food value chain.
ii. The Nigeria port infrastructure should be made to positively impact on agricultural yield by way of government increased investment in port infrastructure. Government can also concession port infrastructure through public private partnership in order to increase food supply chain efficiency and smooth delivery of fresh food products into Nigeria and timely delivery to other parts of the country.
iii. In order to make shipping technology to significantly increase food supply chain efficiency in Nigeria, there is urgent need for improvement in shipping technology as the current trend may have been obsolete with little or no update due to poor government funding.
iv. The growing employment in the maritime industry calls for more investments in maritime transportation in terms of vessels and other shipping logistics. The government should exploit the relevant private sector in ensuring more employment so as to enhance the capacity of the blue economy in ensuring efficient food supply chain.

References

Ahuja, H. L. (2010). *Economic Growth*. S. Chand Publishing.

Agbakwuru, J. A. & Osuji, J. N. (2024). Economic analysis of potential off shore aquaculture practice to enhance diversi*fication of blue economy in Nigeria, Journal of Applied Sciences and Environmental Management 28*(4) 1251-1257

Bari, A. (2017). Our oceans and the blue economy: Opportunities and challenges. *Procedia Engineering*, 187, 1234-1242.

Bennett, M., March, A., & Failler, P. (2024). *Blue Economy Financing Solutions for the Fisheries and Aquaculture Sectors of Caribbean Island States*. *Fishes*, 9(8), 305.

Choudhary, P., Khade, M., Savant, S., & Musale, A. (2021). *Empowering blue economy: from underrated ecosystem to sustainable industry*. *Marine Agronomy Journal* 1-11

Emenyonu, M. U., Onyemechi, C., Emeaghara, G., Nze, I. C. & Ndikom, O. (2024). Maritime security and blue economy development in Nigeria: A structural equation model, *Maritime Technology and Research* 7(2): 1-17 https://doi.org/10.33175/mtr.2025.272954

Harrod, Roy F (1939). 'An Essay in Dynamic Theory'. *The Economic Journal*. 49(193):14-33.

Heydari, M. (2024). Cultivating sustainable global food supply chains: A multifaceted approach to mitigating food loss and waste for climate resilience. *Journal of Cleaner Production,* 252, 1199-1211.

Ibeaja, U. F., Amadi, K. T. & Dim, H. C. (2022). Government intervention and growth of agricultural sector in Nigeria. African *Journal of Social and behavioral Sciences* 12(2), 15-28

Martinez-Vázquez, R. M., & Milán-García, J. (2021). *Challenges of the blue economy: evidence and research trends*. *Environmental Sciences*, 4(2), 53-62.

Mgbomene, C. (2024a). Diaspora remittances and growth f the agricultural sector in Nigeria. *Journal of Academic Research in Economics* 16(2), 1-15

Mgbomene, C. (2024b). Environmental degradation and food productivity in Nigeria. *Jalingo Journal of Social and Management Sciences* 6(1), 315-327

Nworgu, B.G (2006) Educational Research; Basic Issues and Methodology. *Windon PublishersLtd*, Ibadan.

Osuji, J. N. & Agbakwuru, J. A. (2024). Ocean and coastal resources components and their contributions to sustainable development of Nigeria, *Journal of Applied Sciences and Environmental Management 28*(1) 135-146

Onwude, D. Motmans, T., Shoji, K., Evangelista, R., Gajardon J. *et al.* (2023). Bottlenecks in Nigeria's fresh food supply chain: What is the way forward? *Trends in Food Science & Technology* 137: 55-62

Pane, D. D. P., Tortora, P., Anindito, I. A., & Pertamawati, L. H. (2021). *Blue economy development framework for Indonesia's economic transformation*. *Saruna Journal* 3(2), 1-13

Panigrahi, R. & Singh, N. (2024). Digital technologies and food supply chain: a scoping view from 2010 to 2024, *International Journal of Industrial Engineering and Operations Management*, 1-25 DOI 10.1108/IJIEOM-05-2024-0030

Rouf, M. A., Rahman, M. M., & Rahman, S. M. (2019). *Coming stakes in the ocean: food production, shipping and trade, tourism, ecosystem-biodiversity, new* *technologies and climate change challenges in Bangladesh*. *Journal of Coastal Economics*, 6(2), 1-12.

Solow, R. (1956). *A Contribution to the theory of economic growth*. *The Quarterly Journal of Economics*, 70(1), 65-94.

Tigchelaar, M., Leape, J., Micheli, F., & Allison, E. H. (2022). The vital roles of blue foods in the global food system. *Global Food Security*, 32, 1-10.

United Nations General Assembly Document A/AC.105/749 (2000).http://www.unoosa.0rg/pdf/reports/ac105/AC105_749E.pdf

World Bank. (2017). *The Blue Economy: A Framework for Sustainable Development*. World Bank Group.

World Bank (2023). Comparative data on maritime transport employment rate, and Liner Shipping Connectivity Index. www.data.worldbank.org