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TOWARD A SUSTAINABLE BLUE ECONOMY: EXAMINING THE EFFECT OF TRADE, AND ECONOMIC GROWTH ON GREENHOUSE GAS EMISSIONS IN NIGERIA

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Abstract

The concept of blue economy first introduced in 2010, highlights the use of marine resources for sustainable economic growth, jobs creation, marine health, and to improve living standards. However, climate change in form of global warming, ocean acidification, and lack of knowledge about the ocean resources posit serious challenges for sustainable blue economy. Therefore, the main objective of this study is to investigate the dynamic effect of greenhouse gas emissions, economic growth, trade openness and financial development on blue economy resources in Nigeria spanning the period from 1990 to 2022. The innovative dynamic autoregressive distributed lag (D-ARDL) model was employed to achieve this objective, while fully modified ordinary least square (FMOLS) and canonical cointegrating regression (CCR) were applied for robustness check. The results of the dynamic ARDL model indicate that a rise in greenhouse gas emissions and economic growth raise blue economy resources both in the short term and in the long-run, Similarly, trade openness and financial development are positively linked to blue economy resources. Finally, the results from the FMOL and CCR models confirmed the findings of the dynamic ARDL model. Based on the findings, the study recommends that, government should encourage the promotion and preservation of the blue economy resources in Nigeria, while leveraging sustainable economy, trade and financial development and reducing greenhouse gas (GHG) emissions, through the use of environmentally friendly aquaculture systems such as Integrated Multi-Trophic Aquaculture (IMTA), Recirculating Aquaculture Systems (RAS), and organic aquaculture. These methods reduce environmental impact, improve fish health, and increase production efficiency.

Keywords: Blue economy, greenhouse gases, trade, environment, Nigeria.

JEL Classification Codes: F23, N77, Q22, Q25, Q57

1. Introduction

In the recent decade, the concept of the Blue Economy or Oceans/Marine Economy has continued to garner significant attention because it is a relatively new field of research. This concept, which emerged prominently from the United Nations Conference on Sustainable Development held in Rio de Janeiro in 2012, aims to balance economic development with environmental sustainability. Since the oceans and seas constitute the backbone of the global economy and offer great potential for development and innovation, blue growth fosters the long-term expansion of maritime and marine industries. It is the sustainable and responsible utilization of ocean and aquatic resources supports economic growth, enhances livelihoods, and ensures environmental preservation. This economy encompasses diverse sub sectors, including fisheries, aquaculture, maritime transport, tourism, renewable ocean energy, marine biotechnology, and conservation. The United Nations defines the blue economy as an ocean economy that seeks to enhance human well-being and social equity while significantly reducing environmental risks and ecological scarcities. Similarly, the World Bank describes the blue economy as the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems (World Bank, 2017).

There is ongoing discussion on the interplay of the blue economy with two often competing objectives: The potentials for economic growth and development and innovation as well as the need to protect threatened and vulnerable marine spaces on the other hand (Voyer et al., 2018). This inherent conflict necessitates solutions that leverage the economic potential of the ocean economy while recognizing and mitigating its environmental threats. The United Nation Sustainable Development Goals (SDGs), particularly SDG 14, emphasize that economic development should be both inclusive and environmentally friendly, calling for a balance between the economic, social, and environmental dimensions of sustainable development in relation to oceans (Griggs et al., 2013).

For over decades, the Maritime Stakeholders Forum, alongside industry experts, has consistently called for a review of the enabling laws governing the maritime sector to catalyze the blue economy and unlock its full potential. The rationale behind this call is due to the rise and recent development of the blue economy concept in various forums highlighting its significance as an alternative economic model for sustainable development, and recognizing nations' reliance on the oceans (UNECA, 2016). Nigeria possesses enormous aquatic and marine resources with the potential for the growth of the blue economy. The country boasts a coastline extending 420 nautical miles and an exclusive economic zone of 200 nautical miles, Nigeria's maritime interests span approximately 574,800 square nautical miles within the Gulf of Guinea, covering a coastline of 2,874 nautical miles. But all the while, this natural gift has been underutilized. The recent establishment of a Ministry of Marine and Blue Economy in Nigeria signifies a strategic effort to integrate the nation's abundant marine resources into its economic framework. (Olalekan, 2023). The exploitation of these marine resources offers significant potential for employment and income generation through sectors such as fisheries, aquaculture, tourism, shipping, and renewable energy. However, realizing this potential requires a careful balance between economic exploitation and environmental conservation.

While the blue economy continued to receive greater attention which is often discussed as a strategy for sustainable development, a significant research gap exists. There is a lack of empirical studies assessing Nigeria's progress in aligning its marine sectors with the objectives of SDG 14 particularly between 1990 to 2023. Additionally, the interconnections between greenhouse gas emissions, trade, and economic growth within the context of Nigeria's marine resources remain under explored. These gaps call for more analysis on the socioeconomic impacts of blue economy initiatives in Nigeria. Finally, specific research on the impacts of climate change on Nigeria's unique coastal and marine environments is needed to better understand the challenges and opportunities for sustainable marine resource management. Addressing these gaps could provide crucial insights and guide effective policy-making. Therefore, to achieve its objectives, this study seeks to answer the following questions: what has been the progress in blue economy resources in Nigeria from 1990 to 2023 in line with SDG 14? does the relationship between greenhouse gas emissions, trade and economic growth support sustainable blue economy (SDG 14) in Nigeria during this period?

The subsequent sections are structured as follows: review of relevant literature, the methodology employed, result analysis and discussions, and last part concludes by summarizing key findings and offering policy recommendations based on the study findings.

2. Literature Review

The blue economy has gained global prominence since the introduction in the West in the 1990s. Although its definition varies, the term generally describes the interplay between economic growth and ecological sustainability (Silver et al., 2015; Bueger, 2015). It is often viewed through four primary perspectives: oceans as natural capital, sources of livelihood, platforms for innovation, and opportunities for business development (Cisneros-Montemayor, 2019; Voyer et al., 2018). Globally, the blue economy contributes significantly to economic growth, accounting for approximately 3-5% of global GDP.

2.1 Theoretical Framework

The Environmental Kuznets Curve (EKC) has become a widely recognized framework for evaluating the interplay between economic growth and environmental outcomes. Initially introduced by Simon Kuznets in 1955 to describe the relationship between income inequality and per capita income, the concept was later adapted to environmental studies, giving rise to the well-known inverted U-shaped relationship (Kuznets, 1955). This adaptation has since established the EKC as a fundamental theoretical tool in exploring how economic progress influences environmental degradation (Grossman & Krueger, 1991). The Environmental Kuznets Curve (EKC) hypothesis offers a pivotal framework for analyzing the relationship between environmental quality and economic development, asserting that environmental degradation initially escalates with economic growth but eventually diminishes as higher income levels enable the adoption of sustainable practices (Rashid & Viswanathan, 2018). In the context of Nigeria's blue economy, this hypothesis provides valuable insights into the dynamic interplay between greenhouse gas emissions (GHGE), trade openness, financial development, and economic growth, all of which impact marine resources.

Greenhouse gas emission (GHGE), characterized as global stock pollutants, present critical environmental challenges due to their cumulative and persistent nature. However, empirical evidence such as (Ning & Song, 2020) suggests that as economies evolve, adaptive mechanisms such as technological advancements and regulatory frameworks can mitigate the adverse effects of these emissions on marine ecosystems. This further demonstrated that investments in renewable energy and sustainable fishing practices can offset the negative externalities of economic activities on aquatic biodiversity.

This study advances the EKC discourse by integrating its principles with the sustainable management of Nigeria's blue economy resources. It underscores the complex interactions between local and global pollutants, differentiating between short-lived and stock pollutants, and examines the economic-environmental trade-offs inherent in these relationships. By situating the analysis within Nigeria's unique socio-economic and environmental context, the research elucidates pathways through which economic expansion can align with the sustainable utilization of marine resources. The findings are expected to provide evidence-based insights for policymakers and stakeholders, guiding strategies that harmonize economic growth with environmental preservation in Nigeria's blue economy sector.

2.2 Empirical Review

In recent years, the blue economy and environmental sustainability have gained significant attention, especially regarding the geopolitical factors shaping long-term sustainability. The growing discourse around CO_2 emissions, economic growth, and trade has become prominent in both developed and developing countries' economic literature. Policymakers and economists are seeking strategies to achieve a balance between economic growth and environmental health. Several studies have examined ocean-related issues (e.g., Upadhyay & Mishara 2020; Martínez-Vázquez et al. 2021; De la Vara et al., 2020; Fratila et al., 2021; Roberts et al., 2021; Kontovas et al. al. 2022, Zhao et al., 2022; Hafez et al. 2023).

Countries like India, with extensive coastlines shared with six neighboring countries, have leveraged marine resources for economic development through oceanic trade, mineral exploitation, and energy resource utilization (Llewellyn & English, 2016). In South Asia, regions like the Bay of Bengal, which borders countries such as Myanmar, Sri Lanka, and Indonesia, are crucial to marine-based economies. Advancements in marine science and technology have improved the green total factor productivity in these economies (Ning & Song, 2020). Fishing is a major livelihood for coastal communities, contributing 5-8% of income, with the Bay of Bengal being a significant seafood producer (Funge-Smith et al., 2012).

China's blue economy has significantly contributed to its economic growth. The marine industry's share of GDP rose from 6.46% to 13.83% between 2000 and 2011, employing over nine million people (Colgan & Kildow, 2013; Zhao et al., 2014). Similarly, fish consumption in India and other SAARC economies has increased alongside the blue economy's growth (Delgado et al., 2003). In the Asia-Pacific region, Bhattacharya and Dash (2020) analyzed blue economy activities in fisheries and tourism across 21 countries. Their findings highlight the positive impact of capital formation and electricity access on the blue economy, stressing the need for sustainable ocean governance. In Africa, Kakonge (2019) discussed the blue economy's prospects in Kenya, pointing out challenges like capacity shortages, inadequate research, and funding constraints. Okemwa (2019) similarly studied how Kenya could harness its blue economy for sustainable development, recommending an Integrated National Maritime Policy to boost economic growth.

Vázquez et al. (2021) used bibliometric analysis to explore scientific output in the blue economy and its connection to the circular economy, revealing a growing trend over the last decade. In Nigeria, Elisha (2019) found that terrorism, ecosystem destruction, and piracy hinder the blue economy, while Abiodun (2021) emphasized Nigeria's potential, recommending better maritime data management and investment. Adenigbo et al. (2023) investigated the impact of shipping trade on Nigeria's economy, concluding that imports significantly affect long-term GDP growth, while exports do not. Lastly, Adi (2023) examined the blue economy's impact on employment, poverty reduction, and economic growth in Nigeria's Niger Delta. The study highlighted challenges such as illegal arms trafficking, pollution, and climate change, recommending policy reforms to address these issues for the sustainable growth of the blue economy.

3. Methodology

3.1 Data Sources and Justification

This study used annual time series data for the period from 1981 to 2022 for a comprehensive sample of Nigeria, where data is available relating to the aquaculture production, Total fisheries production, trade openness and GDP per capita sourced from the World Bank's World Development indicators (WDI). Moreover, the determination of the sample is solely based on data accessibility, suitability, model specifications, and making key policy suggestions for the growth of Nigeria's blue economy.

Table 3.1: Description of the Variables

Variables	Code	Description	Source
Total greenhouse gas emissions	GHGE	Greenhouse gas emissions (measured in kilotons of CO_2 equivalent) consist of CO_2 emissions, excluding short-cycle biomass burning (e.g., agricultural and savanna burning), but include other biomass burning (e.g., forest fires, post-burn decay, peat fires, and the decay of drained peatlands). They also encompass all anthropogenic sources of methane (CH_4), nitrous oxide (N_2O), and fluorinated gases (HFCs, PFCs, and SF_6).	WDI, WB
Aquaculture Production	ACP	Aquaculture production, measured in metric tons, refers to the farming of aquatic organisms such as fish, mollusks, crustaceans, aquatic plants, and other activities specifically aimed at cultivating these species for final harvest and consumption.	WDI, WB

Total fisheries production	TFP	Total fisheries production, measured in metric tons, represents the total volume of aquatic species harvested by a country. This includes catches for commercial, industrial, recreational, and subsistence purposes, as well as yields from mariculture, aquaculture, and other forms of fish farming.	WDI, WB
Trade openness	TOP	Trade is the total value of a country's exports and imports of goods and services, expressed as a percentage of its gross domestic product (GDP).	WDI, WB
GDP per capita	RGDP	GDP per capita (constant 2015 US$) is calculated by dividing a country's gross domestic product (GDP) by its midyear population. GDP represents the total gross value added by all resident producers in the economy, including product taxes and excluding subsidies not accounted for in the product values.	WDI, WB
Domestic credit to private sector (proxy for financial development)	FD	Domestic credit to the private sector (% of GDP) measures the financial resources supplied to the private sector by financial institutions. This includes loans, purchases of non-equity securities, trade credits, and other accounts receivable that create repayment obligations.	WDI, WB

3.2 Model Specification

In line with the reviewed literature, Alharthi and Hanif (2020) model, which analysed the blue economy's impact on SAARC countries' economy was adapted with slight modifications. Therefore, adapting this pattern, the model is specified as follows:

$$BLE = \beta_0 + \beta_1 GHGE_t + \beta_2 GDPP_t + \beta_3 TOP_t + \beta_4 FD_t + \varepsilon_t \quad (3.1)$$

Where β_1- β_4 are the parameter coefficients of the explanatory variables. BLE is the composite function of aquaculture production, and total fisheries production formed using Principal Component Analysis (PCA), GHGE is the total greenhouse gas emissions, GDPP is the gross domestic products per capita proxied for economic growth, TOP is trade openness, FD is the financial development, and ε is the error term which is assumed to be normally distributed.

For the purpose of estimation, there is need to log-linearize the model in Equation (3.1). This is necessary in order to minimize fluctuations in the data and to streamline the scales of the variables.

$$BLE = \beta_0 + \beta_1 \ln GHGE_t + \beta_2 \ln GDPP_t + \beta_3 \ln TOP_t + \beta_4 \ln FD_t + \varepsilon_t \quad (3.2)$$

3.3 Estimation Procedure

It is critical to employ appropriate techniques for empirical estimations and conduct preliminary tests to ensure the validity of the results, thereby enabling robust policy implications. Among these preliminary tests, assessing the stationarity of variables is particularly important to mitigate the risk of spurious regression. In this regard, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were utilized to evaluate the stationarity properties of the dataset. However, conventional unit root tests may yield unreliable outcomes in the presence of structural breaks. To address this limitation, the study applied the Lee-Strazicich unit root test, which is specifically designed to account for structural breaks when determining the stationarity of variables. Following the stationarity analysis, the Autoregressive Distributed Lag (ARDL) bounds testing approach, as proposed by Pesaran et al. (2001), was adopted to examine the co-integration relationships among the selected variables:

$$\begin{aligned} \Delta BLE_t = {} & \alpha_0 + \alpha_1 BLE_{t-1} + \alpha_2 \ln GHGE_{t-1} + \alpha_3 \ln GDPP_{t-1} + \alpha_4 \ln TOP_{t-1} \\ & + \alpha_5 \ln FD_{t-1} + \sum_{i=0}^{q} \beta_1 \Delta BLE_{t-1} + \sum_{i=0}^{k2} \beta_2 \Delta \ln GHGE_{t-1} + \sum_{i=0}^{k3} \beta_3 \Delta \ln GDPP_{t-1} \\ & + \sum_{I=0}^{K_4} \beta_4 \Delta \ln TOP_{t-1} + \sum_{I=0}^{K_4} \beta_4 \Delta \ln FD_{t-1} + \mu_t \end{aligned} \quad (3.3)$$

In the Equation (3.3), β_i indicates short-term coefficients, while long-term coefficients are denoted by α_i with I = 1…. n. The immediate effect of independent variables on dependent variables is determined by short-run analysis, while the long-run report notes the speed of adjustment toward equilibrium level. BLE is the dependent variable, with optimal lag q; while $\ln GHGE_t$, $\ln GDPP_t$, TOP_t, and FD_t are the independent variables, with k_i optimal lags.

The ARDL bounds testing approach involves comparing the estimated F-statistic with the critical values provided by Pesaran et al. (2001). The null hypothesis of no co-integration is formulated as H0: $\phi_1 = \phi_2 = \phi_3 = \phi_4 = 0$. If the computed F-statistic exceeds the upper bound critical value, the null hypothesis of no co-integration is rejected, indicating a long-run relationship among the variables. Conversely, if the F-statistic lies below the lower bound critical value, the null hypothesis cannot be rejected, confirming the absence of co-integration. When the F-statistic falls between the lower and upper bounds, the evidence for co-integration remains inconclusive.

To address the limitations of the traditional ARDL methodology, particularly after establishing a long-run co-integration relationship, this study employed the Dynamic Autoregressive Distributed Lag (D-ARDL) model, as advanced by Jordan and Philips (2018). This innovative approach offers several advantages, including the ability to dynamically visualize and graphically forecast positive and negative changes in the variables, explore the intertwined short-run and long-run relationships, enhance accuracy, and address the complexities associated with the standard ARDL model (Udeagha & Ngepah, 2022).

The D-ARDL model also boasts additional benefits: (i) It is particularly effective in cases where convergence speeds differ. (ii) It can accommodate variables irrespective of their order of integration, as long as none are integrated of order I(2). (iii) The model facilitates the creation of detailed graphical representations, such as area plots, that capture positive and negative shocks from regressors and their impacts on the response variable (Inuwa et al., 2024).

In this study, we adopt the D-ARDL model in its error correction specification, leveraging Equation (3.2) as the baseline framework and drawing upon the simulation methodologies introduced by Jordan and Philips (2018). This approach enables a robust exploration of the relationships and dynamics among the study variables.

Using Equation (3.2) as the baseline model for this study, and following the work of Jordan and Philips (2018), we provide the novel dynamic ARDL simulations framework in the error correction specification as follows:

$$\Delta BLE_t = \alpha_0 + \alpha_0 BLE_{t-1} + \rho_1 \Delta \ln GHGE_t + \phi_1 \ln GHGE_{t-1} + \rho_2 \Delta \ln GDPP_t + \phi_2 \ln GDPP_{t-1} + \rho_3 \Delta \ln TOP_t + \phi_3 \ln TOP_{t-1} + \rho_4 \Delta \ln FD_t + \phi_4 \ln FD_{t-1} + \hbar ECT_{t-1} + \mu_t \qquad (3.4)$$

The error correction term (ECT), which signifies the speed of adjustment toward long-run equilibrium, must be negative and statistically significant to confirm time series convergence. To ensure the robustness and reliability of the model, several diagnostic tests were conducted as post-estimation measures. The Breusch-Godfrey test was applied to identify autocorrelation in the residuals, while the White test was used to detect heteroscedasticity, indicating any non-constant variance in the error terms. The Ramsey RESET test assessed model specification to ensure no significant variables or functional forms were omitted, and the Jarque-Bera test evaluated whether the residuals followed a normal distribution. Furthermore, the stability of the model over time was verified using the CUSUM and CUSUMQ tests, which graphically examine the consistency of the regression coefficients.

3.5 Robust Analysis

To check the consistency of results, this study employed fully Modified Ordinary Least Square(FMOLS) and Canonical Cointegrating Regression (CCR) models to explore the relationship between the dependent and the independent variables, because FMOLS estimator is characteristically unbiased, fully efficient mixture with normalized asymptotic and is also optimal estimates of cointegration regressions that modifies OLS to correct serial correlation and endogeneity in the regressor as a result of the existence of long run relationships (Inuwa, et al, 2022). Also, the Canonical Cointegrating Regression (CCR) model, in addition to correcting the asymptotic bias, and its ability to eliminate endogeneity caused by the long-run correlations of cointegration equation errors and stochastic regressor innovations, it is also capable of eliminating the long-run dependence between cointegrating equation and stochastic variable.

4. Results and Discussion of Findings

4.1. Descriptive Statistics

The summary of the statistical properties of the study variables are presented in Table 4.1, which reveal that the mean and median values are approximately the similar, standard deviation reveals the volatile nature in the variables, with TOP having the highest volatility, followed by FD compared to BLE, GHGE, and GDPP.

Table 4.1: **Summary Statistics**

Variables	BLE	TGHG	GDPP	TOP	FD
Mean	0.127389	12.59049	7.814836	93.83933	13.25405
Median	0.458091	12.61062	7.826229	107.7896	12.85203
Maximum	0.776307	12.71363	7.893406	119.3200	19.62560
Minimum	-1.692028	12.40528	7.682510	0.249279	10.24658
Std. Dev.	0.809493	0.091716	0.059582	34.06061	2.903722
Skewness	-1.371323	-0.642970	-0.755218	-1.715089	1.220100
Kurtosis	3.479933	2.471758	3.114949	5.347284	3.394675
Jarque-Bera	4.199237	1.046869	1.242924	9.357757	3.309771
Probability	0.122503	0.592482	0.537158	0.009289	0.191114

Source: Author's computation

4.2 Unit Root Tests

The Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests are employed to examine the stationarity of the variables. The results indicate that all variables are integrated of order I(1) at first difference, except for FD. Table 4.2 provides a detailed summary of the order of integration for each variable. Given the mixed order of integration (I(0) and I(1)) among the study variables, the novel dynamic ARDL model is deemed appropriate for analyzing the relationships between the independent and dependent variables.

Table 4.2: Unit root test

Variables	ADF Test		Phillips Perron Test	
	At Level	At 1st Difference	At Level	At 1st Difference
LBLE	-3.379770(0.0753)	-4.874873(0.0058)	-1.780484(0.6905)	-5.077048(0.0014)
LGHGE	-2.162010(0.4923)	-5.528396(0.0005)	-2.247638(0.4479)	-6.524897(0.0000)
LGDPP	1.693220(0.7301)	-2.968481(0.0491)	-1.795538(0.6833)	-2.598051(0.0112)
TOP	-0.065145(0.9931)	-4.355689(0.0093)	-0.630552(0.9692)	-4.355689(0.0093)
FD	-3.691574(0.0381)	5.214266(0.0012)	-2.077189(0.5383)	-6.588783(0.0000)

Source: Author's computation

Unit Root Test with Structural Breaks

The classical (ADF & PP) unit root tests presented in Table 4.3 do not take structural shocks into account, hence the use of Lee and Strazicich LM test. The empirical findings from Table 4.3 indicate that, in the presence of two structural breaks, the variables are I(0) and I(1), hence the use of dynamic ARDL approach.

Table 4.3: Unit root test with structural breaks

	Lee Strazicich LM at Level		**Lee Strazicich LM at first difference**	
Variables	*T*-statistics	Break points	*T*-statistics	Break points
LBLE	-6.032194	2003 2011	-8.394743***	2005 2017
LGHGE	-4.922338**	2003 2014	-9.672048***	2004 2009
LGDPP	-8.209964***	2004 2018	-4.283420***	2001 2003
TOP	-6.710921*	2000 2009`	-15.01635***	2005 2016
FD	-7.933864**	2004 2009	-8.137877***	2002 2007

Note: ***, ** and * show significance at 1%, 5% and 10% levels respectively

Source: Authors' computations.

4.4 Lag Length for F- Bound Cointegration Test

The result of the optimal lag length is presented in Table 4.4:

Table 4.4: VAR **Lag Length Selection Result**

Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	-153.1815	NA	0.055546	11.29868	11.53657	11.37141
1	-47.74888	165.6799*	0.000184*	5.553491	6.980853*	5.989850*
2	-21.10912	32.34827	0.000197	5.436366*	8.053196	6.236357

**Indicates lag order selected by the criterion*

Source: Author's Computations.

The lag order selection by five different criteria in Table 4.4 suggested a lag length of one as the optimal for the F-bound cointegration test.

4.5 Bound Test for Cointegration

The study conducted a Bounds test to assess the long-run relationships among the variables. The results reveal the existence of cointegrating relationships, as the F-statistic value of 5.179958 exceeds both the lower and upper critical bounds, as presented in Table 4.5.

Table 4.5: ARDL Bound Test Results

Model: ***BLE=f(GHGE, GDPP, TOP, FD)***	**95% critical values**		
Null Hypothesis for Error Correction	2.86	4.01	F-Stats
No long-run relationship $\beta_1 = \beta_2 = \beta_3 = \beta_4$			5.179958**

Note: **indicates 5% statistical significance level

Source: Authors' Computations using EViews 10

4.6 Results from Dynamic ARDL Simulations Approach

The result of ARDL dynamic simulations is displayed in Table 4.6.

Table 4.6: Dynamic ARDL Simulation Result

Variables	**Coefficients**	**T-Stats**	**Prob.**
Cons	-17.3292	-1.03	0.314
L-LTGHG	0.866038	3.65	0.005
D_LTGHG	.5521643	0.52	1.211
L_LGDPP	.8366534	2.65	0.031
D_LGDPP	1.107246	-2.06	0.042
L_TOP	.0005144	0.08	0.938
D_TOP	.0039597	2.32	0.032
L_FD	.0230225	2.04	0.041
D_FD	.0077364	0.41	0.689
ECM (-1)	-0.177284	-5.496947	0.0000
R-Squared	0.904835	*Adjusted R-squared*	0.888974
F-Statistics	9 .073331223		0.0428

Source: Authors' Computations using EViews 10

As shown in Table 4.6, the long-run relationship between total greenhouse gases (GHGE), gross domestic product per capita (GDPP), and financial development (FD) is significant at the 5% level, while the variable TOP is not significant. The long-run coefficients indicate that a 1% increase in GHGE will result in a 0.86% rise in blue economy resources. In the short run, a 1% increase in GHGE will lead to a 0.55% increase in blue economy resources. This outcome is supported by the result of Akter et al. (2024) from 25 selected countries surrounding the Indian Ocean, and Badîrcea et al. (2021) from the 28 European Union (EU) countries. For GDPP in the long-run, 1% increase results in 0.84% rise in BLE resources, while in the short term, it results in 1.11% increase in BLE resources, confirming the findings of Okemwa (2019) in Kenya, and

Vazquez et al. (2023) in European countries where they emphasized the importance of economic growth and development in fostering sustainable blue economy. Trade openness is insignificantly positive in the long run, but significant in the short run. It can be seen that 1% increase in TOP promotes BLE by 0.0005% in the long term and 0.0039% in the short-term corroborating the findings of Akter et al. (2024) used a panel dataset of 25 selected countries. For financial development, 1% rise in FD in the long-run induces BLE by 0.023% and 0.008% in the short-run, supporting the findings of Yulisti et al. (2024) & Hong & Thanh (2023) in European countries.

The Error Correction term is negative, with a coefficient estimate of -0.177284, indicating that approximately 17.70% of any movements into disequilibrium are corrected in subsequent periods. With a t-statistic value of -5.496947, the coefficient is highly significant. This coefficient reflects the speed of adjustment from the short run to the long-run in response to disequilibrium and long-run causality relationships. The R-squared value is 90%, with an adjusted R-squared of 88%, and the F-statistic is 9.07, demonstrating the model's fitness based on the probability scores.

Residual diagnostics, including the Breusch-Godfrey serial correlation test, Breusch-Pagan-Godfrey heteroskedasticity test, Jarque-Bera normality test, and stability tests using the CUMSUM and CUMSUM of Squares, were conducted. The results, displayed in Table 4.7 and Figures 4.1 and 4.2, confirm the stability of the model. The stability tests are validated as the CUMSUM and CUMSUM of Squares graphs remain within the upper and lower red bands. All diagnostic tests show significant results, indicating no signs of heteroskedasticity, non-normality, or serial correlation, thus ensuring the model's stability.

Table 4.7: Diagnostic Statistics Tests.

Diagnostic Statistics Tests	F(p Values)	Results
Breusch–Godfrey LM test	0.6365(0.5386)	No problem of serial correlations
Breusch–Pagan–Godfrey test	1.5349(0.2165)	No problem of heteroscedasticity
Ramsey RESET test	2.6549(0.1169)	Model is specified correctly
Jarque–Bera Test	1.9360(0.3798)	Estimated residuals are normal

Source: Authors' Computations.

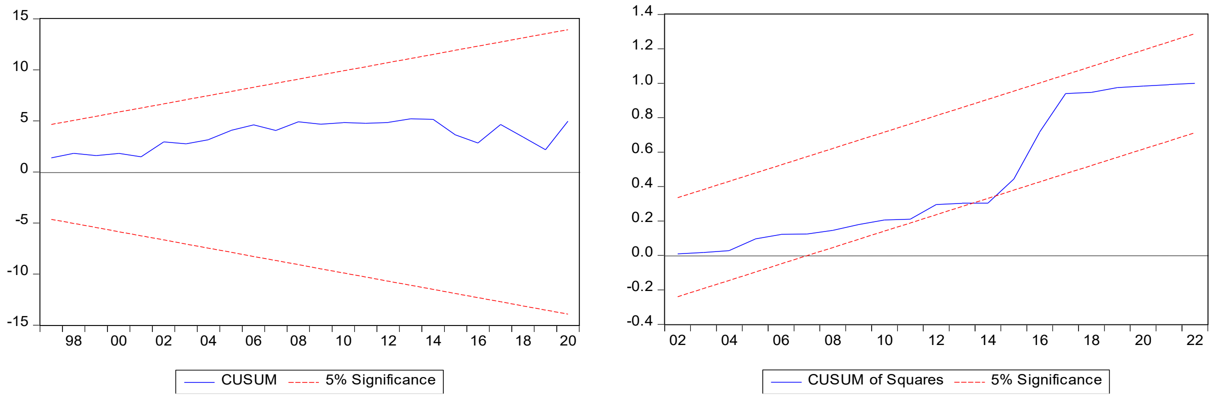

Figure 4.1: Plot of CUSUM and CUSUM of Square**.**

To further reveal the impact of the explanatory variables on the dependent variable so as to have a clear guide for policy implication, the impulse response obtained from the dynamic ARDL simulations have been presented in Figures 4.2-4.5. It is clearly seen in Figure 4.2 that the positive changes in GHE in Nigeria positively affects the blue economy resources, while its negative shocks negatively affect the blue economy resources. Similarly, the effect of positive and negative shocks in economic growth is revealed in Figure 4.3. It is evidently clear that the positive and negative shock of diesel price have significant impact on blue economy resources respectively. Figure 4 depicts the nexus between trade openness and blue economy resources using an impulse-response plot. The plot depicts that 10% increase in trade openness indicates a strong long-term and short-term positive impact on BLE, while a 10% decrease in trade openness indicates a negative impact on BLE in the short-run, and long-run. Moreover, a positive shock in financial development demonstrates an indifferent impact on BLE both in the short-run and long run.

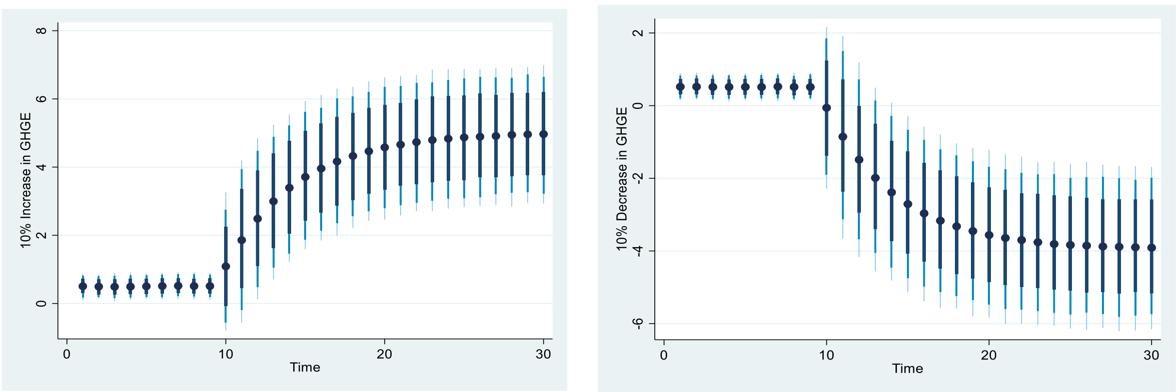

Figure 4.2. Effect of changes in GHGE on the blue economy resources

Figure 4.2 presents a 10% increase or decrease in greenhouse gas emissions and the effect on the blue economy resources in Nigeria.

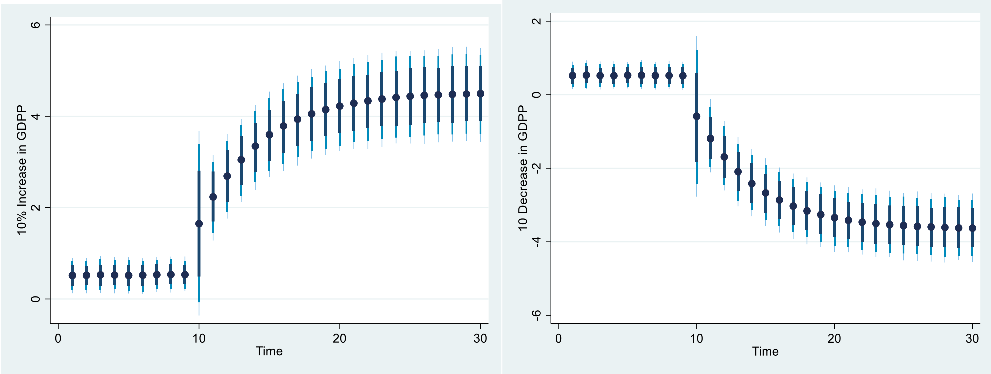

Figure 4.3. Effect of economic growth on the blue economy

Figure 4.3 presents a 10% increase or decrease in economic growth and the effect on the blue economy resources in Nigeria.

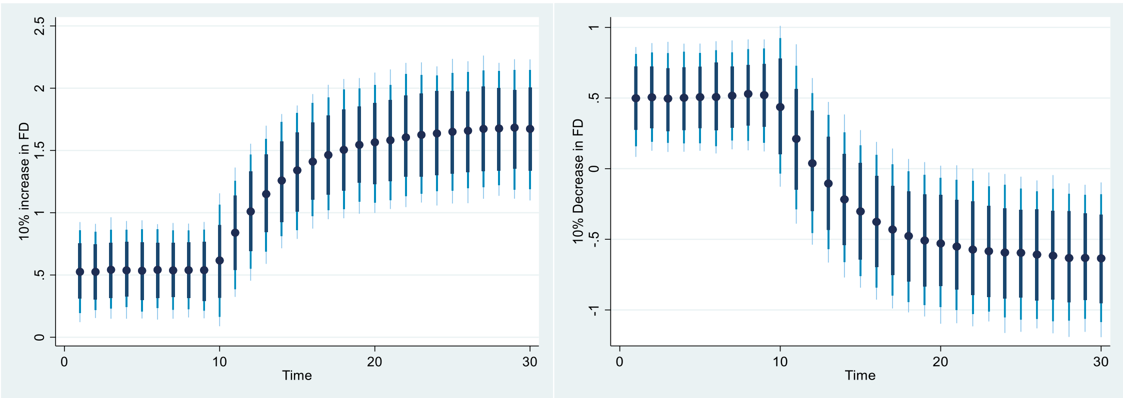

Figure 4.4. Effect of financial development on the blue economy

Figure 4.4 presents a 10% increase or decrease in financial development and the effect on the blue economy resources in Nigeria.

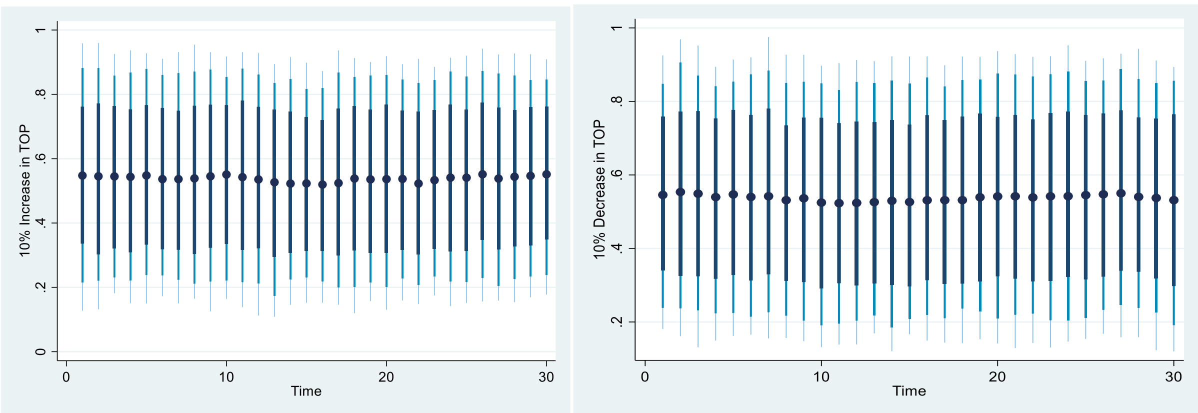

Figure 4.5. presents a 10% increase or decrease in trade openness and the effect on the blue economy resources in Nigeria.

4.4.2 Robust analysis

To assess the consistency and reliability of the estimated results, this study utilized the Canonical Cointegrating Regression (CCR) model as a robust estimation technique. The results of the CCR model are presented in Tables 4.8 and 4.9.

Table 4.8 Robust analysis using Fully Modified OLS

Variables	Coefficient	Std. Error	t-Statistic	Prob.
LGHGE	7.447921	1.797761	4.142888	0.0004
LGDPP	2.970391	0.854935	3.474407	0.0020
FD	0.078144	0.044592	1.752431	0.0925
TOP	0.002791	0.004226	0.660438	0.5153
C	-116.6109	18.00067	-6.478145	0.0000
R-squared	0.942391	Mean dependent var	-0.000691	
Adjusted R-squared	0.932789	S.D. dependent var	1.390971	

Source: Author's Compilation using Eviews 10

Table4.9: Robust analysis using Canonical Cointegrating Regression Model.

Variables	Coefficient	Std. Error	t-Statistic	Prob.
LGHGE	8.164063	2.161656	3.776763	0.0009
LGDPP	2.681628	1.004241	2.670302	0.0134
FD	0.079040	0.046338	1.705737	0.1010
DTOP	0.014096	0.016926	0.832769	0.4132
C	-123.4510	21.22361	-5.816684	0.0000
R-squared	0.904835	Mean dependent var		-0.000691
Adjusted R-squared	0.888974	S.D. dependent var		1.390971

Source: Author's Compilation using EViews 10.

The result shows that the FMOLS and CCR model results are consistent with the previous estimation methods i.e., the novel dynamic ARDL, only the value of coefficient varies slightly.

5. Conclusion and Policy Recommendations

Literature examining the impact of greenhouse gas emissions and economic growth on blue economy resources in the current context are limited. Therefore, the objective of this study is to identify the dynamic effects of greenhouse gas emissions, economic growth, trade openness, and financial development on blue economy resources. This study aims to make a significant contribution to this area and holds particular importance for systematically understanding the dynamic influence of greenhouse gas emissions and other key macroeconomic indicators on Nigeria's blue economy resources. Results of the dynamic ARDL model indicate that a rise in greenhouse gas emissions is positively related to blue economy resources, in both short-run and long-run. Similarly, advancement in economic growth raises blue economy resources both in the short term and in the long-run, trade openness and financial development are positively linked to blue economy resources. Considering its findings, this study recommends that, improving the blue economy in Nigeria, especially aquaculture and fisheries production, while leveraging sustainable economy, trade and financial development and reducing greenhouse gas (GHG) emissions, government should promote the use of environmentally friendly aquaculture systems such as Integrated Multi-Trophic Aquaculture (IMTA), Recirculating Aquaculture Systems (RAS), and organic aquaculture. These methods reduce environmental impact, improve fish health, and increase production efficiency. Also, tax holidays, subsidies, or low-interest loans for fish farmers to invest in energy-efficient systems, solar-powered equipment, and low-emission feed production processes will incentivize the adoption of low-carbon aquaculture technologies in Nigeria and promote water recycling practice and efficiency in the use of freshwater resources in aquaculture systems to reduce the ecological footprint of fish production.

This study also recommends that Nigeria should take advantage of its multilateral trade agreements to promote exports of sustainably produced fishery and aquaculture products. This can be achieved through compliance with the international food safety standards such as Hazard Analysis Critical Control Point (HACCP), lower import tariffs on blue economy technology, renewable energy equipment, and fish feed to promote the expansion of the sector and encourage trade partnerships that focus on sustainable fisheries and environmentally friendly technologies. Furthermore, providing micro-funding and other credit programs to small-scale fish and aquaculture farmers will provide them the opportunities needed to invest in eco-friendly equipment and adopt sustainable practices. Finally, government should establish educational and vocational training programs for the fish farmers and fisheries workers, including training in climate-smart aquaculture techniques, water management, and renewable energy use so that they will be equipped with the knowledge and skills to adopt sustainable practices.

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