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Pathways to environmental quality: Assessing the roles of government expenditure, money supply and trade openness in Nigeria

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Abstract

This study examines the dynamic interplay between government expenditure, money supply, and trade openness and their combined effects on environmental quality in Nigeria from 1986 to 2025. Employing annual time series data and the Johansen cointegration and Vector Error Correction Model (VECM) techniques, the analysis captures both the short- and long-run relationships among the variables. The results indicate a stable long-run equilibrium, wherein fiscal policy exerts a positive influence on environmental quality through green-oriented public investment and sustainable expenditure patterns. Conversely, monetary expansion contributes to environmental degradation by increasing liquidity and promoting carbon-intensive production. Trade openness, although beneficial for economic integration, is found to deteriorate environmental quality, reflecting the pollution haven effect under weak regulatory enforcement. Economic growth supports the Environmental Kuznets Curve (EKC) hypothesis, implying that environmental quality improves once income surpasses a certain threshold. The study concludes that achieving environmental sustainability in Nigeria requires the integration of macroeconomic stabilization policies with climate-responsive frameworks. It recommends adopting green fiscal and monetary instruments, strengthening climate-conscious financial regulation, and implementing environmentally responsible trade reforms to enhance resilience, foster private-sector participation, and align economic growth with low-carbon development pathways.

Keywords: Economic growth, Environmental quality, Government expenditure, Green macroeconomic policy, Money supply, Nigeria, Trade openness, VECM.

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Contents

Contribution of this paper to the literature
The contribution of this study lies in jointly examining government expenditure, money supply and trade openness as macroeconomic determinants of environmental quality in Nigeria using VECM over 1986-2025. Unlike studies that examine these policy channels separately, this study provides an integrated macro-environmental framework with policy implications for green macroeconomic management.

1. Introduction

Environmental quality has emerged as a central policy concern for resource-dependent economies such as Nigeria, where the interplay between economic growth, fiscal-monetary frameworks, and ecological integrity has become increasingly complex. The seminal Environmental Kuznets Curve (EKC) hypothesis proposed by Grossman and Krueger (1991) posits that economic growth initially exacerbates environmental degradation but subsequently improves environmental quality as income rises and societies demand cleaner environments. This relationship underscores the significance of macroeconomic policies such as fiscal, monetary, and trade in determining environmental outcomes (Mahmood et al., 2022).

In Nigeria, fiscal and monetary policies have traditionally been oriented toward economic stabilization and growth, often with limited attention to their environmental consequences. Yet, growing evidence suggests that these macroeconomic instruments significantly influence greenhouse gas (GHG) emissions and overall environmental performance. Fiscal policy, through taxation, public spending, and subsidies, directly shapes production and consumption patterns that drive emissions (Mughal et al., 2021). Targeted fiscal interventions such as carbon taxes, environmental levies, and green public investments have proven effective in promoting ecological sustainability (Dongyan, 2009). In contrast, expansionary fiscal measures without environmental safeguards may amplify pollution via scale effects.

On the monetary side, recent scholarship emphasizes the pivotal role of green monetary measures in supporting the transition to low-carbon economies (Battiston, Mandel, Monasterolo, Schütze, & Visentin, 2017; Campiglio et al., 2018; Reinders, Schoenmaker, & van Dijk, 2020). The NGFS (2019) advocates for incorporating climate-related financial risks into monetary policy frameworks to ensure macro-financial stability and resilience. Effective green financing and climate-conscious credit allocation can reduce carbon emissions per unit of currency spent (Wiethe, 2022). However, in Nigeria, monetary easing has often been directed toward general industrial and consumption growth rather than low-carbon sectors, thus limiting its environmental effectiveness (Omodero, 2023).

Empirical evidence indicates that Nigeria's macroeconomic instruments such as capital expenditure, taxation, broad money supply, and inflation remain critical determinants of the country's environmental outcomes (Abbass, Song, Khan, Begum, & Asif, 2022; Kamal, Usman, Jahanger, & Balsalobre-Lorente, 2021). Between 1977 and 2021, Nigeria's carbon dioxide (CO_2) emissions rose from 66.5 to 123.2 million metric tons, primarily due to fossil-fuel-driven growth, though emissions declined slightly to 122.6 million metric tons in 2022 following heightened environmental awareness and regulatory efforts (Worldometers, 2024). Despite recent reforms, including the introduction of environmental taxes under the 2023 Fiscal Policy Measures, such as excise duties on single-use plastics and import adjustment taxes on high-emission vehicles, their implementation and fiscal channeling remain uncertain, limiting their potential impact on Nigeria's climate goals.

The theoretical and empirical literature highlights that money or capital is indispensable for enabling the transition to a low-carbon economy (Bhandary, Gallagher, & Zhang, 2021). Monetary arrangements, alongside anthropogenic drivers of climate change, influence output growth and environmental resilience (McKibbin, Morris, Wilcoxen, & Panton, 2020). Fiscal distributions, when aligned with environmental objectives, can reinforce sustainable development through targeted investments in clean energy, industrial efficiency, and ecological innovation (Li, Hu, Shi, & Wang, 2021; Omodero, 2023). Nevertheless, Nigeria's fiscal and monetary frameworks are yet to fully internalize environmental externalities in their policy design and execution.

Given these dynamics, this study seeks to examine the impact of fiscal, monetary and trade measures, specifically government expenditure, broad money supply, and trade openness, on environmental quality in Nigeria from 1990 to 2025. By empirically assessing these interconnections, the study aims to contribute to the evolving discourse on green macroeconomics and provide policy-relevant insights for aligning Nigeria's economic growth trajectory with global sustainability objectives.

2. Literature Review

2.1. Theoretical Framework

The Environmental Kuznets Curve (EKC) serves as the foundational theoretical framework for this study, positing an inverted-U-shaped relationship between economic growth and environmental degradation (Grossman & Krueger, 1991). According to the EKC hypothesis, environmental degradation tends to increase in the initial phases of economic development due to industrialization and resource exploitation (scale effect), but eventually decreases as income reaches a higher threshold owing to technological advancements, improved public awareness, and environmental regulations (Mahmood et al., 2022). This theory integrates elements of economic growth, energy use, and policy interventions, making it highly relevant for analyzing resource-dependent economies like Nigeria.

The EKC framework also emphasizes that different economic sectors contribute variably to environmental outcomes. For example, the industrial sector is often associated with increasing emissions, while the services sector could have a mitigating impact as economies mature (Falade & Adeyemi, 2023). Additionally, the framework has been extended to incorporate the role of macroeconomic policies such as fiscal, monetary, and trade in shaping environmental performance, stressing that policy instruments can either accelerate or delay the transition along the EKC curve (Mahmood et al., 2022; Omodero, 2023).

2.2. Empirical Review

Empirical evidence exploring the nexus between macroeconomic policies and environmental quality reveals diverse yet converging insights across economies, including Nigeria. Early frameworks such as the Environmental

Kuznets Curve (EKC) by Grossman and Krueger (1991) provided the foundational premise that economic growth initially worsens environmental quality through scale effects, but may subsequently enhance it as income, technology, and regulations improve. Building on this, recent studies have examined how fiscal, monetary, and trade policy instruments mediate this growth-environment relationship across various economic contexts.

2.2.1. Government Expenditure and Environmental Quality

Government expenditure plays a critical yet context-dependent role in determining environmental outcomes. In high-income and emerging economies, fiscal expansion tends to increase CO_2 emissions through intensified industrial and consumption activities, but its environmental impact depends largely on the composition and governance of spending. For instance, Mahmood et al. (2022) showed that in GCC countries, higher government spending correlates with increased emissions due to scale effects; however, when fiscal measures promote green innovation and environmental taxation, emissions are mitigated. Similar dynamics are observed in Nigeria, where Omodero (2023) found that public expenditure directed toward capital formation without environmental safeguards tends to exacerbate emissions, whereas investment in green infrastructure and institutional capacity yields potential environmental benefits. Ulucak, Danish, and Kassouri (2020) further highlighted that integrating fiscal measures with environmental taxation and globalization can enhance emission reduction outcomes.

Cross-country evidence reinforces these findings. Neves, Marques, and Patrício (2020) examined 17 European Union economies from 1995-2017 and reported that environmental regulations, renewable energy policies, and foreign direct investment (FDI) significantly reduced emissions, supporting the pollution halo hypothesis. Likewise, Le and Ozturk (2020), in a panel of 47 emerging economies (1990-2014), found that expansionary fiscal policy can increase the capacity to acquire renewable technology and green products. They further emphasized that the financial sector and globalization accelerate emissions unless moderated by effective governance and sustainable financing frameworks. Similar evidence from Japan (Ahmed et al., 2022) indicates that fiscal allocations toward clean energy and nuclear infrastructure substantially reduce CO_2 emissions. Zhang, Mohsin, Rasheed, Chang, and Taghizadeh-Hesary (2021) also found that public spending on clean technology research supports green innovation and sustainable development by accelerating renewable energy consumption.

Evidence from long-run analyses across advanced economies provides additional nuance. Yilanci and Pata (2022), using bootstrap causality tests for G7 countries (1875-2016), observed that public spending contributes to emission reduction, although the EKC relationship was not validated over the long term. In Turkey, Katircioglu and Katircioglu (2018) confirmed that between 1960-2013 public spending as a share of income reduces emissions and supports the EKC hypothesis. Collectively, these studies underscore that the environmental impact of fiscal policy depends on its orientation, such as green-targeted spending promotes environmental quality, while growth-oriented but unregulated expenditure often intensifies ecological degradation.

2.2.2. Money Supply and Environmental Quality

Monetary policy influences the environment primarily through its effect on investment, production, and financial flows. Expansionary monetary measures can increase liquidity, stimulate output, and consequently heighten emissions, particularly in fossil-fuel-based economies. Mahmood et al. (2022) documented such patterns in GCC economies, whereas Wang and Zhi (2016) highlighted that the adoption of green monetary policy tools, including green credit and low-carbon finance, has enabled renewable energy investment and pollution control in several economies. In Nigeria, Omodero (2023) noted that traditional expansionary monetary policy often undermines the effectiveness of emerging green finance initiatives, while Schoenmaker (2021) cautioned that without institutional reforms, monetary expansion may neutralize environmental policy gains.

Broader empirical evidence offers similar conclusions. Qingquan, Khattak, Ahmad, and Ping (2020) examined Asian economies between 1990-2014 and found that increasing money supply raises CO_2 emissions, whereas contractionary policies reduce them. However, they also observed that excessive monetary tightening may suppress investment in technological innovation, potentially delaying transitions toward cleaner production. Their findings further indicated that human capital reduces emissions, while remittances and fossil fuel consumption worsen environmental quality. Using Australian data between 1972-2014, Qingquan et al. (2020) demonstrated that expansionary commercial and monetary actions elevate CO_2 emissions, while contractionary policies reduce them, reinforcing the short-term trade-off between growth and environmental quality.

Vo and Zaman (2020), in a study of 101 economies (1995-2018), confirmed the EKC relationship between income and emissions, suggesting that most economies remain in the early, environmentally intensive growth phase. They also found that FDI and energy consumption accelerate emissions, and rising money supply exerts upward pressure on CO_2 through feedback mechanisms involving income and investment. Thus, the global evidence supports the premise that monetary policy is an indirect but powerful determinant of environmental outcomes, mediated through financial deepening, technological investment, and production structures.

2.2.3. Trade Openness and Environmental Quality

Trade and globalization exhibit dual environmental effects depending on regulatory strength and technological diffusion. Mahmood et al. (2022) found that trade openness facilitated technology transfer and emission reduction in GCC countries, yet noted that weak environmental regulations can reverse these benefits by encouraging pollution-intensive activities. In Nigeria, studies have associated FDI and industrialization with higher emissions, consistent with the scale effects described by Khan, Godil, Yu, Abbas, and Shamim (2022). Nevertheless, initiatives promoting renewable energy, sustainable industrialization, and circular economy practices have shown potential to align trade integration with improved environmental outcomes (Mahmood et al., 2022; Omodero, 2023).

2.3. Research Gap

The reviewed literature indicates that government spending, money supply, and trade openness collectively shape environmental trajectories, though their effects vary by economic structure, policy coordination and institutional quality. For Nigeria, the evidence remains fragmented with most studies addressing these policies in

isolation rather than jointly. Therefore, this study contributes to the literature by empirically investigating the joint effects of government spending, money supply, and trade openness on environmental quality in Nigeria from 1990 to 2025, bridging the gap between single-policy analyses and integrated macro-environmental frameworks. The findings aim to inform policy strategies that harmonize economic growth objectives with sustainable environmental management in developing economies.

3. Methodology

This section outlines the research design, data sources, model specification, and methods of data analysis used to examine the role of government expenditure, money supply, and trade openness on environmental quality in Nigeria from 1986 to 2025. The study aims to analyze both the short- and long-term effects of macroeconomic policy instruments on environmental outcomes such as carbon emissions.

3.1. Sources and Types of Data

This study used annual time series data for the period 1986 to 2025 for a comprehensive sample of Nigeria, where data is available relating to carbon emissions, government expenditure, broad money supply, inflation, exchange rate, and gross domestic product are 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 Nigeria's environmental sustainability.

3.2. Model Specification

The functional relationship for the model is specified as:

$$ENV_t = f(GEXP_t + MS_t + TO_t + GDP_t + EXR_t + INF_t) \quad (1)$$

Where:

ENV_t = Environmental Quality (proxied by CO_2 emissions per capita).

$GEXP_t$= Government Expenditure.

MS_t= Money Supply.

TO_t = Trade Openness (measured by: imports + exports as % of GDP).

GDP_t= Gross Domestic Product (proxy for economic activity).

EXR_t= Exchange rate.

INF_t = Inflation rate.

The econometric model is expressed in log-linear form.

$$\ln(C0_2) = \beta_0 + \beta_1 ln(GEXP_t) + \beta_2 ln(M2_t) + \beta_3 ln(TO_t) + \beta_4 ln(GDP_t) + \beta_5 ln(EXR_t) + \beta_6 ln(INF_t) + \varepsilon_t \quad (2)$$

Where:

$\ln C0_2$= Natural log of carbon dioxide emissions.

$GEXP_t$= Government expenditure.

$M2_t$= Broad money supply.

TO_t= Trade openness.

ε_t = Error term.

3.3. Estimation Procedures

It is essential to employ appropriate econometric techniques and conduct preliminary diagnostic tests to ensure the validity and reliability of the empirical results, thereby providing a sound basis for policy implications. Accordingly, the stationarity properties of the variables were first examined to mitigate the risk of spurious regression. In this regard, the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root tests were applied to assess the time series characteristics of the dataset. Subsequently, the Johansen cointegration test was employed to determine the existence of long-run equilibrium relationships among the variables. Given evidence of cointegration, a Vector Error Correction Model (VECM) was estimated to capture both the short-run dynamics and the long-run adjustments toward equilibrium. Furthermore, Granger causality tests were conducted to examine the direction of causality between macroeconomic policy variables and environmental quality.

3.4. Robust Analysis

Diagnostic tests were conducted to validate the model's assumptions and ensure the reliability of the estimated results. These included the Breusch-Godfrey test for autocorrelation, White's test for heteroscedasticity, and the Jarque-Bera test to examine the normality of residuals. The stability of the model over time was assessed using the CUSUM and CUSUMSQ tests, while alternative model specifications and estimators were also considered to verify the robustness of the findings. Collectively, these procedures confirmed the consistency, stability, and policy relevance of the estimated model.

Table 1 presents the descriptive statistics of the variables used in the study, including their mean, median, maximum, minimum, standard deviation, skewness, kurtosis, Jarque-Bera statistics, probability values, and number of observations.

Table 1. Descriptive statistics.

Variables	LCO2	LGEXP	LMS	LRGDP	LEXCR	INFL	TRD
Mean	4.621	7.340	28.805	26.371	4.618	105.016	0.236
Median	4.634	7.610	28.902	26.395	4.610	66.436	0.224
Maximum	4.875	9.612	31.586	27.006	5.610	421.071	0.476
Minimum	4.319	4.099	24.776	25.755	3.908	2.414	0.039
Std. Dev.	0.157	1.576	2.084	0.480	0.381	109.024	0.121
Skewness	0.012	-0.561	-0.337	-0.043	0.638	1.328	0.244

Variables	LCO2	LGEXP	LMS	LRGDP	LEXCR	INFL	TRD
Kurtosis	1.957	2.247	1.799	1.358	3.600	3.976	2.159
Jarque-Bera	1.497	2.508	2.607	3.718	2.736	11.011	1.299
Probability	0.473	0.285	0.272	0.156	0.255	0.004	0.522
Sum	152.503	242.226	950.550	870.242	152.387	3465.534	7.792
Sum Sq. Dev.	0.791	79.499	138.964	7.365	4.652	380360.200	0.471
Observations	33	33	33	33	33	33	33

4. Results and Discussions

4.1. Stationarity Properties of the Variables

The ADF and PP unit root results presented in Table 2 show that all the variables were non-stationary at their level value, but became stationary after differencing once. This implies that the series is stationary at first-order integration, I(1), which supports the adoption of the Johansen and ARDL bounds co-integration techniques.

Table 2. Results of unit root tests.

Variables	ADF	PP	ADF	PP	Decision
LCO2	-2.83	-2.848	-6.172	-6.356	I(1)
	(0.197)	(0.191)	(0.000)	(0.000)	
LGEXP	-2.915	-2.382	-9.288	-9.288	I(1)
	(0.171)	(0.381)	(0.000)	(0.000)	
LMS	-1.782	-1.205	-3.041	-3.041	I(1)
	(0.689)	(0.893)	(0.042)	(0.042)	
LRGDP	-1.581	-1.772	-2.990	-2.961	(I1)
	(0.779)	(0.696)	(0.046)	(0.049)	
LEXCR	-2.439	-38.974	-4.879	-10.905	I(1)
	(0.354)	(0.000)	(0.002)	(0.000)	
INF	-6.263	-3.019	-3.047	-8.589	I(1)
	(0.000)	(0.142)	(0.042)	(0.000)	
TRD	-1.559	-1.518	-5.915	-5.914	I(1)
	(0.788)	(0.803)	(0.000)	(0.000)	

4.2. Johansen Test for Co-Integration

The major aim of this test is to find out if a linear combination of these integrated variables is stationary over the long run; if it is, then it means co-integration exists among the variables, which further implies that there exists a long-run relationship among the variables.

Table 3 presents the Johansen cointegration test results based on both the trace and maximum eigenvalue statistics and indicates the existence of long-run cointegrating relationships among the variables.

Table 3. The results of the Johansen cointegration test.

Trace Outcomes				
Hypothesized		Trace	0.05	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.852	157.882	69.819	0.000
At most 1 *	0.773	100.793	47.856	0.000
At most 2 *	0.638	56.331	29.797	0.000
At most 3 *	0.478	25.881	15.495	0.001
At most 4 *	0.191	6.377	3.841	0.012
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	**Eigenvalue**	**Statistic**	**Critical Value**	**Prob.****
None *	0.851	57.090	33.877	0.000
At most 1 *	0.773	44.462	27.584	0.000
At most 2 *	0.638	30.450	21.132	0.002
At most 3 *	0.478	19.503	14.265	0.007
At most 4 *	0.191	6.377	3.841	0.012

Note: * indicates rejection of the null hypothesis at the 5% significance level. ** denotes the associated probability (p-value).

4.2.1. Vector Error Correction Model (VECM)

The VECM is an extension of the VAR model that incorporates the long-term equilibrium relationship identified by the co-integration tests. The VECM accounts for the short-term dynamics while ensuring that the variables converge to their long-term equilibrium. The error correction term in the VECM measures the speed at which the variables return to equilibrium after a short-term shock.

Table 4 presents the long-run and short-run estimates from the Vector Error Correction Model (VECM), including the estimated coefficients, standard errors, and t-statistics.

Specifically, the error correction terms in the VECM capture the extent to which changes in environmental quality variables are influenced by the disequilibrium from the previous period, considering the influences of FISC, MON, RGDP, INF, EXR and TRD.

Table 4. Result of VECM for long-run and Short-run effects.

Long-run Estimates			
Variables	**Coefficient**	**Std. Error**	**t-Statistic**
LGEXP (-1)	-0.481	0.112	-4.268
LMS (-1)	0.607	0.120	5.055
LRGDP (-1)	-1.636	0. 214	-7.654
TRD (-1)	1.924	0.209	9.221
LEXCR (-1)	-0.045	0.046	-0.977
Short-run Estimates			
Variables	Coefficient	Std. Error	t-Statistic
C	0.048	0. 139	-0.348
D (GEXP (-1))	-0.127	0.089	-1.433
D (MS (-1))	0.059	0.129	0.456
D (LRGDP (-1))	-0.088	0.461	-0.190
D (TRD (-1))	-0.426	0.276	-1.547
D (EXCR (-1))	-0.084	0.056	-1.520
ECM (-1)	-0.289	0.123	-2.359

The long-run coefficients are reported in Table 4. Government Expenditure (LGEXP) exerts a significant negative effect on CO_2 emissions (-0.481), suggesting that expansionary fiscal interventions are associated with improved environmental quality, possibly through investments in infrastructure and environmental programs. Money Supply (LMS), however, has a significant positive effect (0.607), indicating that monetary expansion increases emissions, likely via higher liquidity, industrial output, and energy consumption.

Economic growth (LRGDP) exerts a strong negative influence (-1.636), confirming the Environmental Kuznets Curve (EKC) hypothesis whereby growth, beyond a certain threshold, contributes to environmental improvement. Conversely, trade openness (TRD) has a large positive and significant effect (1.924), consistent with the pollution haven hypothesis, which suggests that liberalized trade facilitates environmentally harmful activities. The exchange rate (LEXCR) shows a negative but statistically insignificant coefficient, suggesting a weak direct link to emissions. Overall, the long-run dynamics indicate that fiscal discipline and sustainable economic growth enhance environmental quality, while monetary expansion and trade liberalization tend to worsen it.

In the short run, most policy variables, including fiscal, monetary, growth, trade, and exchange rate, do not exert statistically significant effects on CO_2 emissions. This indicates that short-run fluctuations in these macroeconomic indicators have limited immediate impact on environmental quality. However, the error correction term (ECM = -0.289, $p < 0.05$) is negative and significant, confirming convergence toward long-run equilibrium. The magnitude suggests that approximately 29% of any disequilibrium is corrected annually, ensuring that the system gradually adjusts back to its long-run trajectory.

Table 5 presents the diagnostic test results for normality, serial correlation, heteroskedasticity, and model specification, confirming that the estimated model satisfies the relevant diagnostic conditions.

Table 5. Diagnostic statistics tests.

Test	**P-Values**	**Conclusion**
Jarque-Bera Normality Test	0.280	Residuals are normally distributed
Breusch-Godfrey Serial Correlation LM Test	0.280	There is no serial correlation
Breusch-Pagan-Godfrey Heteroskedasticity	0.0778	There is no heteroskedasticity
Ramsey RESET Test	0.678	Model is correctly specified

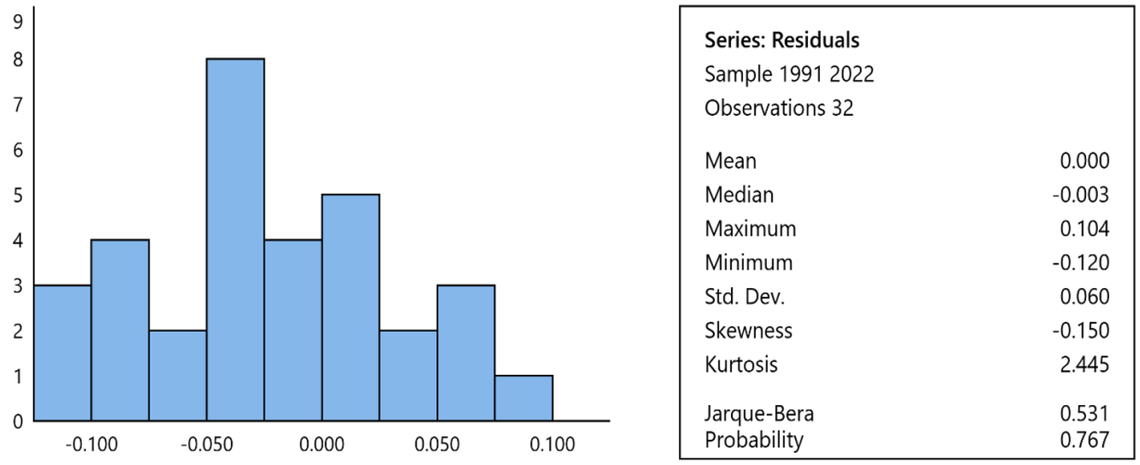

Figure 1. Histogram and descriptive statistics of model residuals.

Figure 1 presents the histogram and descriptive statistics of the model residuals. The residuals are approximately normally distributed, as indicated by the Jarque-Bera probability value of 0.767, which is greater than the 5% significance level. This result supports the normality assumption of the estimated model.

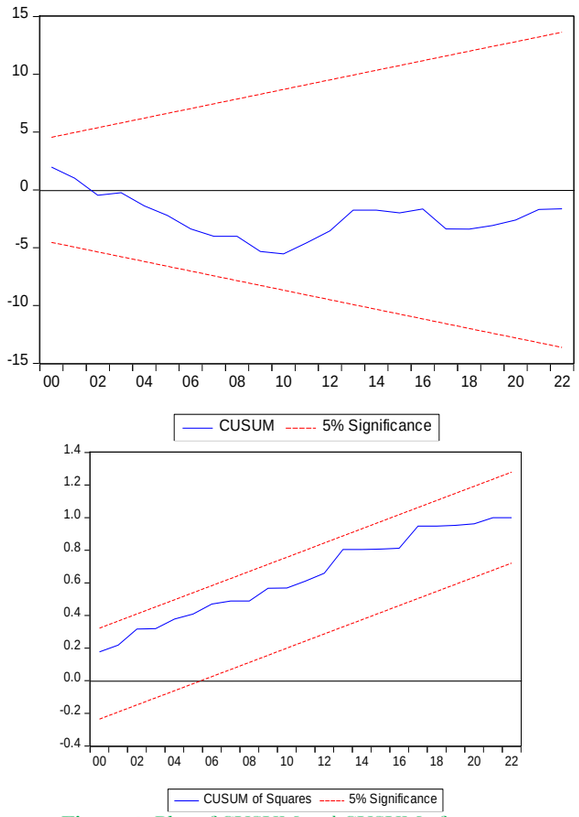

Figure 2. Plot of CUSUM and CUSUM of squares.

Figure 2 exhibits the CUSUM and CUSUM of Squares tests for model stability. The plots remain within the 5% significance boundaries, indicating that the estimated model is stable over the sample period and that there are no major structural instabilities affecting the estimated relationships.

5. Conclusions and Policy Recommendations

5.1. Conclusions

This study examined the macroeconomic pathways to environmental quality in Nigeria, focusing on the influence of government expenditure, money supply, and trade openness over the period 1986-2025. The empirical findings revealed a strong long-run relationship between these macroeconomic variables and CO_2 emissions, underscoring the pivotal role of macro-financial policies in shaping environmental outcomes.

The results demonstrate that government expenditure exerts a negative and significant effect on CO_2 emissions, suggesting that well-targeted public spending can foster environmental improvement through investments in green infrastructure, clean energy, and environmental governance. Conversely, an expansionary monetary stance was found to worsen environmental quality, reflecting Nigeria's continued reliance on carbon-intensive industrial and consumption growth. Trade openness, while essential for economic integration, displayed a positive and significant effect on emissions, validating the pollution haven hypothesis in the Nigerian context. Economic growth, however, had a negative impact on emissions, consistent with the Environmental Kuznets Curve (EKC), which posits that as economies mature, technological progress and environmental awareness drive sustainability transitions.

Collectively, the findings reaffirm that Nigeria's environmental quality is not merely a function of ecological management but is intrinsically linked to macroeconomic policy design and implementation. Hence, effective climate adaptation strategies must integrate fiscal discipline, green monetary frameworks, and environmentally regulated trade liberalization to balance growth with ecological sustainability. This research highlights that the private sector's engagement in climate adaptation depends critically on coherent policy incentives, climate-aligned financing mechanisms, and an enabling macroeconomic environment that rewards low-carbon innovation.

5.2. Policy Recommendations

Based on the empirical findings and theoretical insights, the following policy recommendations are proposed.

1. Institutionalize Green Fiscal Frameworks: Government expenditure should increasingly prioritize low-carbon infrastructure, renewable energy projects, and climate-smart agriculture. Introducing environmental budget tagging, carbon taxes, and performance-based green grants can ensure fiscal alignment with national climate goals.
2. Adopt Climate-Sensitive Monetary Policy: The Central Bank of Nigeria should mainstream green finance instruments such as concessional green credit lines, sustainability-linked bonds, and green refinancing facilities to channel liquidity toward environmentally sustainable enterprises. Monetary authorities should integrate climate risk assessments into macroprudential supervision to protect financial stability under increasing climate shocks.
3. Reform Trade Policy for Environmental Resilience: Trade liberalization should be accompanied by strict environmental standards and eco-certification mechanisms to prevent Nigeria from becoming a pollution haven. Export diversification into green manufacturing and sustainable agricultural value chains will improve environmental outcomes while boosting competitiveness.
4. Enhance Private Sector Participation in Climate Adaptation: Policies should encourage public-private partnerships (PPPs) in renewable energy, waste management, and carbon-efficient technologies. Fiscal

incentives such as tax rebates and accelerated depreciation for green investments can foster private sector innovation in climate adaptation.

5. Strengthen Institutional Coordination and Environmental Governance: Coordination between the Ministry of Finance, Central Bank, and the Federal Ministry of Environment should be reinforced to ensure coherence between economic and environmental policies. Establishing a National Council on Green Macroeconomic Policy could promote integrated decision-making and climate accountability.
6. Invest in Climate Information and Capacity Building: Expanding environmental data systems and analytical capacity will enable evidence-based decision-making. Training policymakers and financial regulators on climate risk modelling and green finance strategies can enhance Nigeria's preparedness for future climate shocks.

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