Lafia Journal of Economics and Management Sciences: Volume 9, Issue 2; 2024
ISSN: 2550-732X
Published by Department of Economics, Federal University of Lafia, Nigeria

Effect of Climate Change on Economic Growth in Nigeria

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Abstract
The research seeks to investigate the climate change effect and the growth of the Nigerian economy, using the model of Autoregressive Distributed Lag (ARDL) to examine the changes of short-time and long-time period for thirty (30) years (1993–2023). Applying the Endogenous Growth Theory as the theoretical framework. The short-time period results reveal that fluctuations in climate change indicators, gross capital formation (GCF), foreign direct investment (FDI), and trade openness (TRO) show inconsistent but significantly impacts on Gross Domestic Product. However, the long-time period, some of these variables demonstrate non-significantly statistical effect on the growth of the economy, suggesting structural limitations within Nigeria's economy that may prevent the full realization of the growth potential of these factors. The Correction in Error Term reveals a slow rate for equilibrium adjusted, highlighting economy's gradual response to deviations from long-term trends. Meanwhile, there is confirmation of model robustness from Diagnostic test, without heteroskedasticity's evidence and residuals from serial correlation, thus supporting the findings' reliability. The study concludes that while climate change, FDI, GCF, and trade openness can influence short-term growth, their long-term impact is hindered by Nigerian economic and structural challenges. Based on the results, the research recommends strengthening regulatory frameworks to improve FDI effectiveness, investing in climate-resilient infrastructure, enhancing the efficiency of capital allocation for productive projects, and diversifying the trade structure to maximize the benefits of trade openness. These strategic recommendations aim to address underlying structural constraints, thereby supporting Nigeria's pathway to sustainable economic growth.

Keywords: Economic Growth, Climate Change, Foreign Direct Investment, Gross Capital Formation, Trade Openness
JEL Classification Codes: Q56, Q54, F43, L71, D24

1. Introduction

One of the present environmental challenges to the existence of man, plant, and animal around the world is climate change. It will be important to be aware of its effect on some of the climatic factors, as it will reveal the degree of urgency for the abatement action, especially for developing countries which might be nonchalant because of the degree of their economic activities. The change in climatic condition change refers to the long-time periodic shift in temperatures and usual weather structures across various regions of the planet. People related activities are mainly responsible for this change in climate. The major greenhouse gases in the atmospheric condition are carbon dioxide, methane, and nitrous oxides, whose accumulation is attributed to the warming up of surface temperatures on earth (Obianuju & Osman, 2023).

The harsh reality of climate change can already be seen in the rising temperatures, sea levels, and drastic weather changes across the globe. Changes pose important risks to human health, agriculture, water resources, ecosystems, and infrastructures. Current global climate models, though not entirely comprehensive, predict a rise in global temperatures ranging from 3.3°C to 5.7°C by 2100 if greenhouse gas emissions continue unchecked, a scenario that would be deeply alarming. These range from increased and more intense droughts, floods, and heat waves to loss of biodiversity and ecosystems, and millions of people losing their homes or their sources of livelihoods due to rising sea levels or other climate-related impacts (Taher, 2019).

Climate change, manifesting as heatwaves, droughts, heavy rainfall, and flooding, is severely disrupting nearly every aspect of our environment, posing a significant environmental and economic risk to the global economy. This results in significantly disrupted weather patterns and extreme climate events, which profoundly impact the performance of climate-sensitive sectors such as agriculture, health, water resources, energy security, and even contribute to conflicts. It is projected that, over the next century, temperatures would rise to a great extent; for that reason, many more widespread and rapid climatic changes are supposed to take place, thus creating a great need to assess the relationship between climatic conditional change and growth of economy. While global warming is a worldwide challenge requiring collective action, the impacts of climate change are unevenly distributed. The severity of its effects differs among countries and regions, influenced by the degree of climate change they face and their ability to adapt (Ojo, 2021).

Numerous studies indicate that climate change will disproportionately impact poorer nations, with Africa being particularly vulnerable due to its dependence on climate-sensitive resources, especially in agriculture and water sectors. The region's food production heavily relies on rainfall, making the

fight against hunger and the pursuit of food security increasingly challenging amid declining rainfall. Moreover, climate change exacerbates existing pressures and hinders Africa's ability to achieve sustainable growth, further entrenching the cycle of poverty. Nigeria hosts Africa's largest mangrove forest, with only 6 percent currently under protection. Its diverse ecological zones support various livelihoods and agricultural activities as vulnerable risks to the impacts of climatic conditional change and environmental shocks (Richard, 2018).

Most cities are being threatened by the levels of emerging sea in the south, like Lagos, and coastal areas, exposing them to increased vulnerability to flooding and waterborne diseases. Drought and declining rainfall, coupled with increasing air temperatures, disrupt Nigeria's hydropower systems, limit agricultural production, and impair fishing activities. These challenges undermine food security, health, and nutrition, ultimately impacting the economy. Additionally, energy use, deforestation, and land-use changes are the primary contributors to Nigeria's greenhouse gas (GHG) emissions. Basically, the country is exposed to change in climatic condition due to reasons that include agricultural reliance, a long coastline, and rapidly growing population. While the consequence of climatic conditional change on the growth of economy might be different for a developed and developing country, the effect in developing countries is more serious, such as in Nigeria, due to technology and adaptation techniques challenges as well as health systems (Dahiru, Hüseyin, & Andisheh, 2021).

The change in climatic condition is apparently occurring, and even little shifts in mean conditions, namely temperature or sea level, has significantly increased the frequency of extreme events, posing severe threats to society. For instance, a 0.2-meter uplift in sea layer could cover 3,400 km of Nigerian coastline. Meanwhile, a 1.0-meter upward would inundate 18,400 km, submerging the oil and gas infrastructural resources of the entire Delta. Apparently, Nigeria is already and adversely facing climatic conditions, which is negatively impacting the well-being of its population. By 2030, an estimated 75 to 250 million people in Africa may face heightened stress from water scarcity, environmental challenges, and food insecurity result to change in climatic conditions. The settlement appropriate for agricultural project, as well as seasonal farming systems and yields, is estimated to have diminished. These findings are supported by the 4th Evaluation Report of the Intergovernmental Panel on Climatic-Condition Change (IPCC) released in 2007.

The African countries which include Nigeria, is expected to be the hardest hit by the climatic conditional change effects, leaving Nigeria particularly as vulnerable. Evidence suggests that while climate change and its impacts will be global, developing countries, especially in Africa, will bear the

brunt due to their limited capacity to adapt. Studies reveal that Nigeria is already contending with environmental issues related with the continuing impactful effects of climatic-condition change. The current data shows global temperature, which has risen by 0.8°C lately during the pre-industrial age, and below a "Business as Usual" (BAU) scenario, it would have approximately reached 2°C by 2060.

If left unchecked, the climatic condition changes as well as warming from the globe may severely affect the populace's sustenance in Nigeria, disrupting agricultural businesses namely farm produce, animal rearing production, forestry, fisheries, and post agricultural business activities. Altered rainfall patterns, rising temperatures and humidity, increased pest and disease outbreaks, and natural disasters will cause significant harm to lives, property, and farmland. These impacts are already evident on a smaller scale in conflict-prone regions like the Niger Delta, the arid northeast, and parts of the northwest.

The increasing impact from climatic condition change is ascribed to the rising competition for very few resources, thereby leading to conflict over available farmland and water resources. The research is therefore meant to investigate the effect of climate change effect on the growth of Nigerian economy. The study is divided into five subsections with the introduction as one. Two is on the clarification of concepts, reviewed theories and the Empirical reviews. Three dwells on the methodological issues. The fourth and fifth sections focus on the findings and discussion as well as the conclusion and recommendations respectively.

2. Literature Review

2.1 Conceptual Clarifications

2.1.1 Climate change

Taher (2019) defines climatic condition change that is marked by global phenomenon through transformations from the Earth's usual climatic patterns namely temperature, precipitation, and wind, largely driven by human activities. These disruptions threaten the sustainability of ecosystems, the future of humanity, and the stability of the global economy. Climate change involves substantial shifts in global temperature, rainfall, wind patterns, and other climatic metrics over several decades or longer. According to James (2020), evidence links many of these extreme changes to rising carbon dioxide and greenhouse gas levels in the atmosphere, primarily caused by human activities.

According to Alepu *et al.* (2018), climate change is characterized by analyzing long-time periodic trends in temperature, precipitation, and other elements like pressure, wind, humidity, and sunlight. It represents a prolonged

alteration in global or regional climate patterns. Similarly, Romer (1986) defines climatic condition change as any significant and lasting change in climate indicators, such as temperature, precipitation, and wind, that persists over an extended period, often spanning decades or longer.

Climatic condition (climate) change describes as substantial variations in ordinary atmospheric conditions over long periods, primarily made by man natural processes such as fossil fuels burning and practices of agricultural activities (afforestation, deforestation and others). The effects of environmental hazards and global warming have resulted from the increment in the levels of greenhouse gas through the atmospheric conditions like rising sea levels and shifting weather patterns (Aghion & Howitt, 1992). It also describes enduring changes in the statistically distributed atmospheric structures, which are ranged through the thousands century of years, encompassing both human-driven global warming and the resulting large-scale shifts in climate systems. While often used interchangeably with "global warming," climate change is a broader term that includes not only the rise in earth's surface temperature, but also other impacts associated with elevated greenhouse gas concentrations. Globally around the earth, Climate change in Nigeria is described as long-time periodic shifts in Temperatures, perception, and atmospheric structures patterns, vastly operated through the increased in greenhouse gas emissions.

2.1.2 Economic Growth

Etim, Umoffong, and Elias (2020) define economic growth as the process through which an economically productive capability expands during the terminal period of time, effecting to a largely degree of national earnings. This emergent maturity is reflected in increased income levels, a larger labor force, higher capital stock, and greater trading transaction and consuming activity. Similarly, Dwivedi (2004) describes growth of economy as a productive upward in per capita national output or net national product during the terminal extended time. According to Etim et al. (2020), economic growth involves deliberate efforts by governments to influence economic variables through fiscal and monetary policies.

The World Bank (2011) describes economic growth as the gross summation of value added by all commercially productive entrepreneurs in economies, including products taxed but excluding subsidized products not actually included in product values, calculated without deducting for capital consumption or resource depletion. Nzotta (2007) emphasizes that economic growth is the increment in products (goods and services produced) by an economy during terminal period of time, typically quantified by the percentage

increment in real gross domestic product (RGDP), which accounts for inflation.

Otu and Adejumo (2013) note that GDP measures the value of monetary tools for all final products (goods and services produced) within a nation during a specific terminal period, namely within quarterly or annually. Economic growth is broadly defined as the expansion in productive and consuming transactions of products (goods and services) during a specific period in an economy, frequently quantified by the growth rate of RGDP. It is a central goal for governments and policymakers as it promotes higher living standards, more employment opportunities, and increased wealth generation.

2.2 Theoretical Review

2.2.1 Greenhouse Gas Emission Theory

Greenhouse gas emission theory propounded by Joseph Fourier in 1824. This theoretical mechanism is explained as the heating of certain atmospheric earth trap (AET) from gases, which leads to the effect of warming, including carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), and fluorinated gases. The theory is centrally understood as climatic condition change and global warming that man actions have made it to be importantly had the increment for the concentration of the gaseous exchange since Industrial Revolution, aggravating and resulting greenhouse effect and globally atmospheric temperature rise. The greenhouse effect is having naturally prcesses where gaseous exchange in Earth atmospheric condition trap some of the Sun light energy, precluding it from leaking back into space and retaining the planet warm sufficient to support life. This effect essentially involves for maintaining Earth's habitable temperature but can be intensified by additional emissions (Arrhenius, 1896).

Specifically, from the combustion of fossil fuels namely coal, oil, and natural gas, deforestation, and industrial processes, man actions significantly emit quantities of greenhouse gaseous exchange into the atmospheric space. Since 20th century, CO_2 emissions from industrial activities have increased dramatically, contributing about 75% of the global warming effect (IPCC, 2021). Greenhouse gases contribute to "radiative forcing," a measure of the change in energy balance in Earth atmospheric space due to greenhouse gaseous exchange emissions. When more greenhouse gaseous exchange emissions accumulate, they enhance radiative forcing, trapping more heat and contributing to climate warming (Myhre, Shindell, Breon, 2013). Greenhouse gas emissions often trigger feedback loops, further amplifying warming. For instance, as atmospheric conditions uplift, polar ice melts, detracting Earth's albedo (reflectivity) and passing much to a greater extent for solar energy to be consumed, turning the warming increment (Hansen *et al.,* 2005).

Each greenhouse gas has a different capacity to trap heat, known as its Global Warming Potential (GWP). For example, methane has a Global Warming Potential above 20 multiplies greater than CO_2 above century period, which makes a potent but shorter-lived greenhouse gas (Environmental Protection Agency, 2021). Increased greenhouse gases contribute to a range of impacts, including higher globally atmospheric conditions with extremely temperature occurrence, sea level upward, and ecosystems and agriculture disruptions. Models predict that the effects could intensify without significant reductions in greenhouse gas emissions (IPCC, 2021).

2.2.2 Endogenous Growth Theory

Endogenous Growth Theory appeared as a responsive limitation to the Solow Swan neoclassical growth model, which emphasized the responsibility of exogenous technologically endowed change in moving the growth of economy (Romer, 1994). Unlike its predecessor, Endogenous Growth Theory posits that growth of economy is mainly the finding of intrinsic factors inside the economy, such as technologically innovative endowment, human capital development, and knowledgeable accumulation (Lucas, 1988). The theory emphasizes the significance of policy measures, institutional frameworks, and investments in research and development (R&D) as key motivators of sustained the growth of economy (Romer, 1986).

The core premise of endogenous growth theory is that economic agents, through deliberate actions, can influence the long-term growth trajectory of an economy. The investments in technologically innovative endowment, human capital development, and knowledgeable reserve spillovers have critical challenged for generating returns that do not diminish over time, thus enabling sustained economic expansion (Aghion & Howitt, 1992). The theory also highlights the role of externalities, such as technological advancements and knowledge diffusion, in enhancing productivity across sectors, which can result to the growth of economy's increment.

From the context of climate change, Endogenous Growth Theory provides a robust framework for understanding how investments in green technologies and sustainable practices can drive economic growth while addressing environmental challenges. This theory suggests that economies can grow by developing and adopting neo-technologies that decrease carbon emissions and prevent the consequences of climatic condition change (Acemoglu, Aghion, Bursztyn, & Hemous, 2012). By fostering innovation in renewable energy, energy efficiency, and sustainable agriculture, countries like Nigeria can achieve economic growth while simultaneously reducing their environmental footprint. The transition to a green economy, supported by

endogenous growth theory, can be a key strategy for mitigating climate change impacts.

Nigeria, as a developing country with significant vulnerabilities to climate change, can leverage this theoretical framework to guide its economic policies. By investing in clean energy, enhancing human capital through education and training in green technologies, and promoting R&D in sustainable practices, Nigeria can achieve a dual objective: fostering economic growth and building resilience to climate change (Bowen & Hepburn, 2014). Nigeria's economy is heavily reliant on naturally endowed resources, specifically oil and gaseous products that importantly factor to gross domestic products and its exporting earnings (Central Bank of Nigeria, 2022). However, this dependence on fossil fuels poses challenges in the face of global efforts to combat climate change. Endogenous Growth Theory offers a pathway for Nigeria to diversify its economy by investing in green technologies and reducing its reliance on carbon intensive industries. By doing so, Nigeria can enhance its economic resilience and position itself as a leader in sustainable development in Africa (Audu, 2015).

Moreover, the theory importantly highlights the human capital significance in driving the growth of economy. Nigeria's youthful population presents an opportunity to develop a skilled workforce that can drive innovation in green technologies and sustainable practices. The investments in educational settings, specifically Science, Technology, Engineering, and Mathematics (STEM) is likely to equip the Nigerian workforce within their necessary skills in order to excel within a green-pasture economy. There is an alignment within the theory of endogenous growth's principles, emphasizing the responsibility of human capital in sustaining long-term growth of economy (Lucas, 1988). To fully harness the potential of endogenous growth theory in addressing climate change and fostering economic growth, Nigeria needs to implement a range of policy measures. First, the government should increase investments in R&D, particularly in green technologies and renewable energy sources (Odularu & Okonkwo, 2009).

Establishing innovation hubs and providing incentives for private sector investments in sustainable practices can stimulate technological advancements that contribute to economic growth. Second, Nigeria should prioritize education and training programs that focus on green skills and knowledge. This will ensure that the workforce is prepared to engage in sectors that are pivotal to a green economy, such as renewable energy, sustainable agriculture, and waste management (Chindo *et al.*, 2020). By building human capital in these areas, Nigeria can enhance its economic productivity and reduce its vulnerability to climate change. Third, the government should implement policies that promote energy efficiency and reduce carbon

emissions. This includes setting regulatory standards for industries, encouraging the adoption of clean technologies, and providing subsidies for renewable energy projects (Oyedepo, 2012).

These measures align with the principles of endogenous growth theory by fostering innovation and enhancing productivity, contributing to the growth of economy. Endogenous growth theory creates a valuable framework for understanding relationship between climatic condition and the growth of economy in Nigeria. By stressing the attribute of human capital, innovative technology, and sustainable practices, the theory offers a pathway for Nigeria to achieve productive growth in economy, while keynoting the objections constituted by climatic condition change. Through strategic investments in green technologies, education, and policy reforms, Nigeria can leverage the principles of endogenous growth Theory to build a resilient and prosperous economy for the future.

2.3 Empirical Review

Imen and Mourad (2022) investigated the climatic condition change's impact and the growth of economy in Africa over both the short-time and long-time, analyzing the 34 selected African nations spanning 1971 to 2019 as a panel data. Employing a model of dynamic panel is tool as a structural multifactor error and using CS-ARDL and CS-DL estimation methods. The study found that climate change adversely affects economic growth in both timeframes. Specifically, a one-degree rise in average temperature was projected to create a significant reduce in real GDP per capita, with a 1.68% decline in the short term and a 2.45% reduction in the long term.

Olaniyi, Ojekunle, and Amujo (2020) explored the challenge of climatic condition change and its environmental impactful effect, discussing various responses to global warming, including mitigation, adaptation, and the potential human suffering resulting from unavoidable effects. The study provides an overview of Nigeria's environment, its preparedness for the impact of global warming, and related challenges. It also highlights the current status of environmental data, emphasizing the need for baseline environmental surveys and the development of a comprehensive database supported by geographic information systems. The authors advocate for increased funding by governments at all levels for geo-information production and its utilization to effectively and proactively address global warming, ensure sustainable environmental management, and promote national development.

Angelis, Giacomo, and Vannoni (2019) examined the link between the growth of economy and qualitative environment in the contextual aspect of Kuznets curve, suggesting growth may previously lead to indirect environmental outward, which it can ultimately provide solutions to

environmental degradation. The study focused on the policies of environment's role, specifically the utilization of market-based and non-market based instrumental techniques to address pollutant substance and reduce climatic condition change. Using determinate changes appraisals for the sample of 32 nations from 1992 to 2012, the results show a modified U-shaped association between per capita of both GDP and CO_2 emissions in a geometric model and an N-shaped pattern in a cubic model. Notably, the stringency indexes (used as proxies for environmental regulation) have indirectly and significantly high coefficients, indicating the effectiveness of policies in decreasing the environmental harm related with the growth of the economy.

Taher (2019) investigated the relationship between climatic condition change and the growth of economy in Lebanon, and the analysis of time series is to be adopted for twenty-four years (1990-2013) with an ordinary least squares estimation technique. The findings show, two climatic condition variables, carbon dioxide emissions and forest area, are negatively correlated with economic growth, while rainfall and temperature changes have a positive effect. However, only rainfall was significantly statistical as well, but other controllable parameters revealed to be significantly aligned with expected theories. Also, the findings suggest that Lebanese policymakers should adopt strategies to decrease the impact of carbon dioxide emissions and deforestation. The study recommends that establishment of a national council is to address climate change-related issues. Co-integration tests, after testing for stationarity, confirm a co-integrating relationship between the variables.

Ogbuabor and Egwuchukwu (2018) investigated the climatic condition change's impact and Nigeria's aggregate growth of economy, using the estimation of ordinary least squares technique with time series data of thirty-four years (1981-2014). They used annual rainfall changes, carbon emissions, and forest depletion as proxies for climate change, along with control variables such as public expenditure, internal private investment, and foreign exchange rates. The findings revealed that there is indirectly impact between carbon emissions and the growth of economy for short- and long run respectively.

3. Methodology

The research depends on secondary data that will be obtained from (World Bank, 2023; Central Bank of Nigeria 2023; and the National Bureau of Statistics, 2023). These sources provided a wide array of data on climate change, economic growth, gross capital formation, trade openness, and population growth rate to assure robustness and reliable consistency of the empirical analysis. The model addresses the objectives of the study and is

adapted from the work of Imen and Mourad (2022) with a few modifications. The study aimed at investigating the effect of climate change on economic growth proxy by Real Gross Domestic Product (RGDP) during the specific years of thirty years (1993-2023). The model specification is stated to functionally show below;

$$RGDP = f(CLC, GCF, FDI, TRO) - - - - - - - - - - - - - - - - (1)$$

The model becomes

$$RGDPt = \beta 0 + \beta 1 CLCt + \beta 2 GCFt + \beta 3 FDIt + \beta 4 TROt + \varepsilon t - - (2)$$

Where;

GDP = real gross domestic product, measured in constant

CLC = Climate change

FDI = Foreign Direct Investment

GFCF = Gross capital formation

TRO = Trade openness

β_0 = intercept, β_1- β_5 are the partial slope coefficients, and

εt = stochastic error term.

4. Results and Discussion

Table 1: Descriptive Statistics

	LRGDP	LCLC	LFDI	LGCF	LTRO
Mean	31.28358	-0.201711	0.272645	4.365611	16.43114
Median	31.28885	-0.203341	0.421196	4.373087	16.57084
Maximum	31.90899	0.444045	1.756279	4.524914	16.81457
Minimum	30.70742	-1.491655	-1.693790	4.163373	15.76376
Std. Dev.	0.467201	0.432996	0.715081	0.114144	0.298842
Skewness	0.053358	-0.953372	-0.365212	-0.176175	-0.777317
Kurtosis	1.373554	3.833335	3.521736	1.795630	2.474406
Jarque-Bera	3.431589	5.593071	1.040729	2.033931	3.478631
Probability	0.179821	0.061021	0.594304	0.361691	0.175641
Sum	969.7909	-6.253051	8.451983	135.3339	509.3654
Sum Sq. Dev.	6.548305	5.624557	15.34024	0.390863	2.679188
Obs.	31	31	31	31	31

Source: Author's Computation Using Eviews 12, 2024

The descriptive statistics provide insights into the central tendencies, variability, and distribution characteristics of the key variables—Real Gross Domestic Product (LRGDP), Climate Change (LCLC), Foreign Direct Investment (LFDI), Gross Capital Formation (LGCF), and Trade Openness (LTRO). The mean value for LRGDP is 31.28, closely aligned with its median, and a low standard deviation of 0.47 indicates minimal fluctuations, reflecting

economic stability over the period. In contrast, LCLC has a mean of -0.20 with a moderate standard deviation of 0.43, suggesting some variability in Nigeria's climate conditions, which deviate occasionally from baseline values. FDI inflows (LFDI) exhibit higher volatility, as shown by a mean of 0.27 and a standard deviation of 0.72, likely driven by external economic conditions and policy shifts.

Gross Capital Formation (LGCF) shows a mean of 4.37 and a very low standard deviation of 0.11, indicating consistent capital investment levels. Similarly, Trade Openness (LTRO) has a mean of 16.43 and moderate variability (standard deviation of 0.30), reflecting the influence of trade policies and global market trends. Skewness and kurtosis values reveal that LRGDP and LGCF are relatively symmetrical with stable distributions, while LCLC and LFDI show moderate left skewness and occasional extremes, highlighting their susceptibility to external shocks. The Jarque-Bera test confirms normality for most variables, except for LCLC, which shows slight deviations due to skewness and peakedness. Overall, Nigeria's GDP, capital formation, and trade openness exhibit stability and consistency over time, while climate conditions and FDI inflows display greater variability and extremes. This underscores the potential for external factors, such as climate variability and investment fluctuations, to impact economic performance.

Table 2: Summary of Unit Root Test Results

Variable	Order of Integ.	ADF Test Stat.	Critical ADF Test Stat.
RGDP	I(1)	-4.307693	-3.603202**
CLC	I(0)	-4.316154	-3.574244**
FDI	I(0)	-5.110256	-3.580622*
GCF	I(0)	-5.563254	-3.452144
TRO	I(0)	-9.885811	-3.574244

Columns 1 and 2 and the tests include intercept with trend; * significant at 1%; ** significant at 5%;*** significant at 10; Mackinnon critical
Source: Author's Computation Using Eviews 12, 2024

The unit root tests' findings show to disclose distinct integration orders across the variables, highlighting their individual characteristics. Real Gross Domestic Product (RGDP) is stationary at first difference, with an Augmented Dickey-Fuller (ADF) test statistic of -4.307693, which surpasses the critical value of -3.603202 at the 0.05 level of significance. This shows that RGDP follows an I(1) process, meaning that it was non-stationary level but became stationary after one differencing. Thus, RGDP exhibits a trend that required differencing to stabilize, suggesting a potential persistence in its time series.

In contrast, Climate Change (CLC), with an ADF test statistic of -4.316154, Foreign Direct Investment (FDI), with a test statistic of -5.110256, Gross Capital Formation (GCF), showing -5.563254, and Trade Openness (TRO), with a notably large test statistic of -9.8858, are all stationary at levels, indicated by their I(0) order. Each of these variables' test statistics exceeds their respective critical values at varying significance levels, confirming that these variables are mean-reverting without differencing. Specifically, CLC and TRO surpass their critical values at the 5% level (-3.574244), FDI at the 1% level (-3.580622), and GCF also indicates stability at its level with a critical value of -3.452144. Hence, the appropriate technique to be utilized is the Auto Regressive Distributed Lag (ARDL) Model. This also implies that the Bounds Test have to be conducted to establish long-term association among the variables. The Bounds test will proffer the required information as to whether the long-run analysis be conducted.

Table 3: Results of Bounds Test

F-Bounds Test		Null Hypothesis: No levels relationship		
Test Statistic	Value	Signif.	I(0)	I(1)
F-statistic	16.73704	10%	2.45	3.52
K	4	5%	2.86	4.01
		2.5%	3.25	4.49
		1%	3.74	5.06

Source: Author's Computation Using Eviews 12, 2024

Table 3 showed that the bounds test for co-integration, with an F-statistic of 16.73704, surpasses the upper critical bound estimate of 4.01 at the 5% level of significance. The outcome shows that we cannot accept the null hypothesis of no long-term association among the variables, confirming a level association exists. Consequently, there is evidence of a stable, long-term equilibrium association between the dependent and independent parameters from the specified model. This result supports the presence of co-integration, meaning the variables move together over time, maintaining a steady relationship even amid short-term fluctuations.

Table 4: ARDL Long Run Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
LCLC	-12.11405	397.5089	-0.030475	0.9776
LFDI	8.639012	279.6770	0.030889	0.9773
LGCF	-1459.157	48948.91	-0.029810	0.9781
LTRO	-163.7716	5402.941	-0.030312	0.9777

Source: Author's Computation Using Eviews 12, 2024

The findings of this study, which indicate non-significant long-run impacts of climate change, FDI, Gross Capital Formation (GCF), and Trade Openness (TRO) on Nigeria's economic growth, differ from several recent studies within Nigeria and the broader West African context, which generally affirm these variables' relevance in driving economic performance. Recent research highlights the substantial negative effects of climatic condition change on economic performance, especially in climatic-sensitive regions like Nigeria. These findings suggest that climate change factors are essential in determining growth trajectories, contrasting with the current study's result of an insignificant relationship between climate change and GDP. This discrepancy might reflect the limitations in data or the need for more refined climate indicators to capture their nuanced effects on Nigeria's economy.

Trade openness is often linked to economic growth through enhanced access to larger markets and greater competitiveness. This study's findings of non-significant effects for climate change, FDI, GCF, and trade openness on Nigeria's economic growth contrast with prior research, which generally supports the growth-enhancing roles of these variables under the right conditions. This divergence may point to contextual factors unique to Nigeria's economic environment, such as inefficiencies in capital allocation, regulatory constraints, or limited absorptive capacity for FDI and trade benefits. Further research incorporating sector-specific data and alternative methodologies might better capture these relationships and yield insights into effective policy adjustments.

Table 5: Short Run Error Correction Result

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	67.03936	4.790885	13.99311	0.0008
D(LRGDP(-1))	0.057210	0.071242	0.803031	0.4807
D(LRGDP(-2))	-0.117122	0.076133	-1.538385	0.2216
D(LRGDP(-3))	-0.577417	0.081728	-7.065078	0.0058
D(LCLC)	-0.055778	0.007502	-7.434733	0.0050
D(LCLC(-1))	0.023967	0.005292	4.529271	0.0201
D(LCLC(-2))	-0.001164	0.005711	-0.203823	0.8515
D(LCLC(-3))	0.023438	0.004203	5.576285	0.0114
D(LFDI)	-0.006712	0.002993	-2.242358	0.1107
D(LFDI(-1))	-0.019269	0.004210	-4.577327	0.0196
D(LFDI(-2))	0.005951	0.004252	1.399545	0.2561
D(LFDI(-3))	0.036474	0.005044	7.230618	0.0055
D(LGCF)	0.728705	1.022191	0.712885	0.5274
D(LGCF(-1))	6.842639	1.182424	5.786959	0.0103
D(LGCF(-2))	-796.6395	56.40595	-14.12332	0.0008
D(LTRO)	-0.181551	0.058304	-3.113871	0.0527
D(LTRO(-1))	1.011387	0.090339	11.19548	0.0015
D(LTRO(-2))	0.864578	0.077572	11.14549	0.0015
D(LTRO(-3))	0.213130	0.064959	3.281000	0.0464
CointEq(-1)*	-0.006242	0.000447	-13.97374	0.0008
R-squared	0.992054	Mean dependent var		0.042784
Adjusted R-squared	0.970486	S.D. dependent var		0.036757
S.E. of regression	0.006315	Akaike info criterion		-7.160326
Sum squared resid	0.000279	Schwarz criterion		-6.200447
Log likelihood	116.6644	Hannan-Quinn criter.		-6.874904
F-statistic	45.99643	Durbin-Watson stat		2.752125
Prob(F-statistic)	0.000015			

Source: Authors Computation Using Eviews-12, 2024

The short-run error correction regression results reveal important dynamics in the relationship between the variables and their force on Nigerian economic growth, particularly in the context of the cointegrating equation represented by the Error Correction Term (ECT). The coefficient for the Error Correction Term (CointEq(-1)) is -0.006242 that shows that there is significantly statistics at the 1% level (p-value = 0.0008). The indirect estimate reveals any deviation from the long-run equilibrium is rectified in the following time. Specifically, the magnitude suggests that approximately 0.6242% of the disequilibrium from the later period will be rectified within the recent time. A smaller coefficient signifies a gradual adjustment process, indicating that while the system tends to revert to equilibrium over time, the adjusted speed is relatively slow.

The R-squared and Adjusted R-squared estimates of 0.992054 and 0.970486 respectively shows a precisely high proportionate of the variation in the explained variable (D(LRGDP)) by the model, and is also indicating a robust fit while penalizing for the complexity of the model. Both metrics support the adequacy of the selected model in capturing the relationships among the variables. The F-statistic and p-value of 45.99643 and 0.000015 respectively, further validates the specified model's overall significance, which the explanatory variables are equal to zero in terms of joint hypotheses of the coefficients. Given that the F-statistic is significantly high, we cannot accept the null hypothesis, confirming that the explanatory variables collectively have significantly effect on the explained variable (D(LRGDP)).

The Durbin-Watson statistic is reported as 2.752125, which reveals the presence of direct (positive) autocorrelation if the value is substantially below 2, and indirect (negative) autocorrelation if it is significantly above 2. Based on this, an estimate larger than 2 suggests a potential issue with positive autocorrelation, indicating that the residuals from the regression may be correlated, which can affect the efficiency of the coefficient estimates. However, as long as the autocorrelation is not severe, the model can still provide useful insights.

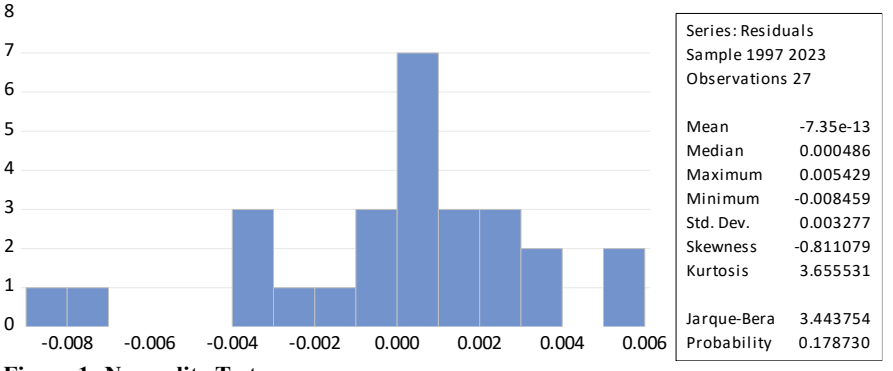

Figure 1: Normality Test
Source: Author's Computation Using Eviews 12, 2024

The normality test for residuals of the model is interpreted using the Jarque-Bera statistic shown in the output. The Jarque-Bera value is 3.444754 with a prob. (p-value) of 0.178730. Since the sig. (p-value) is larger than the formal level of significance (e.g., 0.05), we fail not to accept the null hypothesis of normality, which suggests the residuals are normally and approximately distributed, normally and reasonably distributing in line with the Jarque-Bera test, skewness, and kurtosis. This finding indicates the

assumption of normality is not violated in this model, lending credibility to the statistical inferences drawn from the model's output.

Table 6: Serial Correlation Test Result

F-statistic	2596.768	Prob. F(2,1)	0.0139
Obs*R-squared	26.99480	Prob. Chi-Square(2)	0.0000

Source: Author's Computation Using Eviews 12, 2024

The Breusch-Godfrey Serial Correlation LM Test is used to check for the presence of serial correlation in the residuals of the model, which can affect the reliability of the model's estimates. The F-statistic and p-value show 2596.768 and 0.0139 respectively, in which the conventional significance of 0.05 is greater than the p-value, we fail to accept the null hypothesis of no serial correlation at up to 2 lags. This result suggests evidence of serial correlation in the residuals. The Obs*R-squared statistic is 26.99480 with a p-value of 0.0000. Again, this very low p-value indicates a rejection of the null hypothesis, confirming that serial correlation exists in the model's residuals. The test results opine that there is significantly positive serial correlation in the residuals of the model. This implies that the errors are correlated across time, which could result to non-efficient estimates and potentially unreliable inference. Addressing serial correlation, perhaps by modifying the model (e.g., adding lagged terms or using a different specification), would improve the robustness of the model's results.

Table 7: Heteroskedasticity Test Result

F-statistic	0.248270	Prob. F(22,4)	0.9866
Obs*R-squared	15.58586	Prob. Chi-Square(22)	0.8359
Scaled explained SS	0.255486	Prob. Chi-Square(22)	1.0000

Source: Author's Computation Using Eviews 12, 2024

The Breusch-Pagan-Godfrey test is used to detect the presence of heteroskedasticity, which reveals when the residuals variance is not constant across observations. The null hypothesis in this test is that homoskedasticity (constant variance of residuals) exists. The F-statistic value and p-value is 0.248270 and 0.9866 respectively, in which the conventional significance of 0.05 is lesser than the p-value, we accept the null hypothesis of homoskedasticity. This result reveals no heteroskedasticity evidence based on the F-statistic. The Obs*R-squared statistic is 15.58586 with a p-value of 0.8359, further supporting the conclusion of homoskedasticity. Again, the high p-value suggests that we can accept the null hypothesis. The Scaled Explained SS statistic has a value of 0.255486 with a p-value of 1.0000, reinforcing the previous results by indicating no evidence of heteroskedasticity. The test

results strongly indicate that the residuals of the model exhibit homoskedasticity, as all p-values are well above the 0.05 significance level. This opines that the errors variance is consistent across observations, validating one of the key assumptions of the regression model. Consequently, this improves the reliability of the coefficient estimates and supports the model's robustness.

4.1 Discussion of Findings

The short-run results show significant impacts of several lagged terms of climate change (CLC), FDI, GCF, and TRO on real GDP. However, the coefficients for these variables exhibit mixed signs and statistical significance, indicating that the effects of these variables on economic growth fluctuate over time. For example, certain lagged terms of CLC and FDI show positive impacts on GDP, while others have negative effects, reflecting the volatile nature of these variables in influencing economic performance in the short term. This inconsistency could reflect the seasonal and often unpredictable impact of climate factors on agriculture, which is a crucial sector in Nigeria. Similarly, the mixed effects of FDI in the short term align with studies indicating that while FDI can stimulate growth by bringing in capital and technology, its immediate benefits depend on absorptive capacity and sectoral distribution (Adegbite & Ayadi, 2020). In contrast to the short-run fluctuations, the long-run results reveal that climate change, FDI, GCF, and TRO statistically do not reveal a significantly impactful effect on Nigeria's GDP. This finding diverges from much of the existing literature that underscores the importance of these variables for sustained economic growth in developing countries.

The non-significant long-term effect of climate change contradicts recent empirical research, which generally finds that climate change poses a important threat to economic stability in developing economies by affecting agricultural productivity, health outcomes, and infrastructure (Diffenbaugh & Burke, 2019). This discrepancy may arise from the use of aggregate climate data, which might not capture the sector-specific or region-specific impacts of climate change within Nigeria. Additionally, it suggests that the Nigerian economy may have some adaptive mechanisms that mitigate long-term climate impacts, although this requires further investigation. Similarly, the non-significant long-run impact of FDI suggests that foreign investment in Nigeria may not be effectively translating into sustainable economic growth. This finding is unexpected given that FDI is often cited as a growth driver, particularly in economies with adequate regulatory frameworks and infrastructure (Ogundipe *et al.,* 2022). The absence of a significant long-term effect could indicate structural challenges, such as regulatory constraints,

insufficient infrastructure, or a lack of alignment between FDI inflows and critical sectors that can sustain growth, like manufacturing and infrastructure.

The results for gross capital formation (GCF) are also noteworthy. Typically, GCF addresses a crucial purpose in enhancing productive performance, supporting long-term growth (Eze & Uzochukwu, 2021). Its lack of a significant impact in this study may point to inefficiencies in investment allocation. In Nigeria, issues like mismanagement, corruption, and delayed infrastructure projects can diminish the effectiveness of capital investments, leading to a weak correlation between GCF and GDP growth. This finding aligns with observations from other West African countries, where investment often fails to generate expected economic returns due to similar inefficiencies (African Development Bank, 2022).

Lastly, the non-significant long-term impact of trade openness contrasts with the expected positive relationship posited by economic theory, which links openness to enhanced market access and efficiency (Adeniyi & Aluko, 2022). One explanation for this result is that Nigeria's trade structure is heavily reliant on oil exports, making it vulnerable to international price fluctuations and limiting the broader economic benefits of openness. Additionally, the lack of a diversified export base may reduce the growth-enhancing effects of trade openness, as the economy remains susceptible to external shocks.

The error correction term in the model is statistically and significantly negative, which indicates any short-term deviations from the long-term equilibrium are corrected over time, albeit at a slow rate of 0.6242% per period. This slow adjustment speed suggests that while the model variables eventually revert to a long-term equilibrium, the process is gradual, which could reflect structural rigidities in Nigeria's economy. These rigidities, such as regulatory inefficiencies and market distortions, may slow the speed at which Nigeria's economy adjusts to shocks, underscoring the need for policy reforms that enhance flexibility and resilience. The diagnostic tests support the robustness of the model. The higher R-squared and adjusted R-squared estimates reveal the model explains a significant proportion of the variability in real GDP. Furthermore, the Breusch-Pagan-Godfrey test shows no evidence of heteroskedasticity, and the Breusch-Godfrey test reveals the serial correlation absence, confirming the reliability of the estimates. The normality test findings suggest the residuals are approximately normally distributed, which is essential for making valid statistical inferences.

5. Conclusion and Recommendations

This study investigated the impact of climate change, foreign direct investment (FDI), gross capital formation (GCF), and trade openness (TRO)

on Nigeria's economic growth. The findings reveal that, in the short term, fluctuations in these variables have significant yet inconsistent impacts on real GDP. However, in the long run, none of these variables statistically showed a significantly effect on economic growth. The unexpected result suggests structural challenges in Nigeria's economy that may hinder the full potential of FDI, GCF, trade openness, and climate resilience from contributing to sustained economic development. While the error correction term indicates that deviations from equilibrium are corrected over time, the slow adjustment rate implies that Nigeria's economy faces constraints in adapting to shocks and integrating external influences effectively. The results underscore the need for targeted policies and structural reforms to address inefficiencies and improve the adaptability of the Nigerian economy.

Based on these results, the strategic and practical recommendations are proposed as follows:

i. The government should strengthen regulatory frameworks to create a more favorable environment for investment, particularly by addressing bureaucratic barriers, enhancing transparency, and providing incentives for investments in productive sectors such as manufacturing, technology, and infrastructure. Additionally, policies that encourage reinvestment of profits in Nigeria can help retain capital within the economy, fostering long-term growth.

ii. The government can introduce targeted subsidies or tax incentives for businesses adopting climate-smart technologies, such as irrigation systems for agriculture or renewable energy solutions. Furthermore, establishing a national climate adaptation fund could support these initiatives, ensuring that key sectors are protected from climate-related disruptions that directly impact economic stability.

iii. Nigeria should focus on enhancing the public investment efficiency by improving project planning, monitoring, and execution. Introducing a performance-based budgeting system, where funding is linked to measurable outcomes, can help ensure that resources are directed towards projects with high economic impact. Additionally, prioritizing infrastructure projects that connect rural areas to urban markets could enhance productivity and support more inclusive growth.

iv. The government should promote non-oil exports by creating incentives and confirm for local industries, particularly in agriculture, manufacturing, and services that can compete in international markets. Establishing trade partnerships and engaging in trade facilitation agreements with neighboring West African countries could also enhance market access for Nigerian goods. Investing in export-oriented infrastructure, such as ports and logistics, would further support a diversified trade strategy, allowing Nigeria to benefit more fully from global trade dynamics.

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