



EFFECT OF CLIMATE CHANGE ON ECONOMIC GROWTH IN NIGERIA

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Abstract

The study examined the effects of different components of climate change on economic growth in Nigeria. To achieve this objective, the growth accounting equation framework provided the basis for the models adopted. These models comprised 7 economic growth equations, where each of the five climate change measures and their combination is made to feature differently in the first 6 equations while the five measures are included simultaneously in the seventh equation. The study tested for stationarity of the variables through the ADF method and cointegration of the models through the ARDL Bounds testing approach. Based on the outcomes of these tests, the paper adopted the ARDL estimation method to derive the models' long-run estimates that are reported and evaluated in the paper, after ensuring the validity of the estimates through appropriate diagnostic tests and necessary remedial econometric measures. The data, which covered 1991-2021 years for Nigeria, were sourced from the World Bank and IMF databases. Following the above methodology, the highlights of findings confirmed that each of the following 4 categories of climate change (viz: methane emissions, gaseous emissions, liquid emissions and aggregate emissions) has a negative effect on economic growth in Nigeria. The study therefore recommends that if climate change is mitigated by reducing the consumption of those components where it recorded a negative effect on economic growth, it would increase economic growth.

Keywords: Climate Change, Cointegration, Growth Accounting, Economic Growth, Capital Stock Growth.

JEL: Q54, O4, C32, E13

1. Introduction

Climate change is a worldwide issue that has attracted more attention recently. The resultant effects of climate change include increased global temperatures and harsh weather. The economy is one sector that is especially vulnerable to the consequences of climate change. Understanding how climate change affects economic growth is essential as nations work towards sustainable economic growth. Nigeria, the country with the biggest economy in Africa, is not impervious to the negative consequences of climate change (Opoku, 2021). The country is especially vulnerable to the effects of climate change, which include altered patterns of rainfall, more frequent extreme weather events, and droughts (Okon et al., 2021). These alterations in the environment present serious obstacles to the nation's projected economic growth.

The link between economic growth and climate change has been the subject of numerous studies. Dell, Jones, and Olken (2012), for example, found

that warmer temperatures considerably impede economic growth in developing nations. In a similar vein, Burke, Hsiang, and Miguel's (2015) analysis projected that by the end of the century, global warming may cause a considerable decline in world economic growth. According to another study by Obianyo, Kelechi, and Onwualu (2023), supply chain disruptions and higher production costs resulting from climate change could slow down output growth.

Following from this, the present study has the objective of examining the effects of different measures of climate change on economic growth in Nigeria and, by so doing, offers an insightful analysis that should facilitate evidence-based policymaking in Nigeria and direct the country's efforts towards sustainable economic growth.

The rest of the paper is organised as follows: Section 2 is on the literature review while Section 3 presents the methodology, which includes justification for the inclusion of variables and description of the data

employed. The presentation and analysis of results is done in Section 4 and Section 5, which is the last section, is on the conclusions.

2. Literature Review

2.1 A Review of the Growth Theories

Growth theories explain the factors that determine economic growth. There exist many such theories in the literature. The important and relevant theory reviewed here is the neoclassical growth theory.

Neoclassical growth theory, as narrated by Banton (2023), posits growth in output to be a function of growth in inputs: capital, labour and technological progress. Any increase in savings rate leads to only an increase in both the steady-state level of output per capita and per capita capital stock over time, without any having an effect on the growth rate of output. The growth rate of output remains unchanged due to the law of diminishing marginal product of capital because any further increase in capital will lead to a fall in output back to the steady state. In addition, population growth reduces the steady-state level of capita per head and output per head, as it increases over time, and increases the steady-state growth rate of output. Long-run growth of output also depends on improvement in technology and an absence of this will allow output per person to converge to a steady state value, which depends positively on the savings rate and negatively on the population growth rate (Dornbusch, Fischer, & Startz, 2011).

2.2 Empirical Review

There are various studies on climate change effect on economic growth across the globe. However, this section reviews studies based on global, Africa and specifically Nigeria empirical evidence. To start with the global-level ones, studies by Lee, Mai & Raymond (2016), Gallic & Gauthier (2017), Harries (2008), Dai, Kesternich, Löschel & Ziegler (2015) and Frankhauser & Tol (2005) investigated the effect of climate change on economic growth with the aid of a simple climate-economy simulation model. They found that capital accumulation has a very important effect particularly when technological changes are endogenous. Also, they found that weather shocks played an important role in explaining macroeconomic shocks over the sample period. Kyle and Juliet (2014) used a balanced data set of 29 high-

income countries to investigate the relationship between economic growth and carbon dioxide emissions over the period 1991–2008. Their focus was on the differences between territorial emissions and consumption-based (or carbon footprint) emissions, which include the impact of international trade. They found that the effect of economic growth is greater for consumption-based emissions than territorial emissions. The study carried out by Eboli et al. (2010) used a dynamic computable general equilibrium model (ICES), to assess the economic consequences of climate change impacts. The study employed a set of sectoral impact estimates to simulate and compare two scenarios, with and without climate change impacts. Their finding is in line with the study carried out by Dell et al. (2008) that macroeconomic effects are sizeable but, most importantly, that there are significant distributional effects of climate change at the regional and industrial level.

Regarding the studies on Africa, Abidoye & Odusola (2013), Odusola & Abidoye (2012), Babatunde & Ayodele (2015), Ali (2012), Aragie (2013), assessed the effect of climate change on the economy of African countries' between the periods of 1961 to 2009 in Africa. Annual data were employed and they found that climate changes have negative impacts on economic growth across all the African countries investigated. They also found that an increase in temperature is capable of reducing economic growth in the continent. The studies further stated that the two largest economies in the continent, Nigeria and South Africa, are the ones reducing the negative effects of climate change in the region.

Coming to the studies that are specific about Nigeria, Akanbi, Adagunodo & Satope (2014) investigated the impact of climate change and human development on economic growth in Nigeria during the period of 1985 to 2010, using the least squares regression analysis method. They found that climate change affects economic growth and human development is detrimental. Ojo (2021) examined the potential impacts of climate change on Nigerian economic growth between 1981 and 2017 and found that annual average rainfall has effects on economic growth both in the short-run and long-run. Alehile (2018) examined the effect of climate change on the

performance of Nigeria economy between the period of 1990 to 2017. The study employed an Autoregressive Distributed Lag (ARDL) model estimation method, with real GDP being the dependent variable and labour force, gross capital formation, change in temperature and change in precipitation as explanatory variables. The finding revealed the existence of long-run relationship between climate change variables and real GDP. Also, it was found that, in the short-run, precipitation has a positive effect on real GDP while change in temperature negatively affects real GDP but in the long-run both precipitation and temperature had negative effects on economic performance

The literature on the effect of climate change on economic growth in Nigeria highlights the intricate implications of changing climate patterns on key sectors of the economy. Based on the literature reviewed, effects of climate change have been extensively investigated but many of the studies used temperature and rainfall as the proxies for climate change. The present paper investigates the effect of each component of climate change on economic growth in Nigeria as against the practice in the existing literature of using only either temperature or rainfall or both as the proxies. Specifically, the paper provides an analysis of the effects of different

$$\frac{\Delta Y}{Y} = (1-\alpha) \frac{\Delta L}{L} + \alpha \frac{\Delta K}{K} + \frac{\Delta A}{A} \dots\dots\dots (2)$$

3.2 Model Specification

As a part of the model specification, the rationale for inclusion of the productivity growth ($\frac{\Delta A}{A}$) postulated determinants is first discussed, prior to the mathematical statement of the resulting productivity growth or $\frac{\Delta A}{A}$ equation. Finally, it is this productivity growth ($\frac{\Delta A}{A}$) mathematical expression that will be used to replace the $\frac{\Delta A}{A}$ term in the above growth accounting Equation (6) in order to arrive at the actual economic growth ($\frac{\Delta Y}{Y}$) equation to estimate as a function of the

$$(\frac{\Delta A}{A})_t = \beta_1 GEX_t + \beta_2 LITR_t + \beta_3 FDI_t + \beta_4 COMP_t \dots\dots\dots (3)$$

where $\beta_1 - \beta_4$ = parameters to be estimated, GEX = government expenditure, LITR = literacy rate, FDI = foreign direct investment, COMP = a representative

individual components of climate change on economic growth.

3. Methodology

3.1 Theoretical Framework

This study adopts the growth accounting approach, which is, in turn, an integral part of the neoclassical growth theory, which explains how economic growth is determined by the growth of factors of production and how they are influenced by economic decisions. This study specifically follows Solow's (1957) growth model, which focuses on how capital accumulation and productivity affect long-run per capita output growth. The main idea here is that capital accumulation, labour and autonomous level of technology have effects on growth. The derivation of the growth accounting framework or equation that forms the basis of the models specified in the study starts from a generalised linear homogeneous production function with a neutral technology of the form:

$$Y = Af(K, L) \dots\dots\dots (1)$$

Where Y is the GDP or level of output, K is capital stock, L represents Labour and A is the Productivity or technology level.

$\frac{\Delta L}{L}$ and $\frac{\Delta K}{K}$ as well as all those factors that are postulated as productivity growth ($\frac{\Delta A}{A}$) determinants, including the climate change factors.

3.2.1 Mathematical Equation Specification of the Productivity Growth $\frac{\Delta A}{A}$ (Relationship)

Base on the above, below is the mathematical specification of the model for productivity growth $\frac{\Delta A}{A}$. It is in the form of a time series linear deterministic econometric model and it is as specified as Equation (3) thus:

climate change factor, which stands for each of emissions from the use of natural gas (CGAS), emissions from the use of petroleum-derived fuels

(CLIQ), emissions from the use of coal (CSOL), emissions from stemming from human activities (METEM) and emissions from burning and livestock management (NOEM)

In line with the earlier discussion on the expected directions of effects of the explanatory variables, the narratives on the a priori expectations of their effects that were contained there can now be stated mathematically in terms of the expected signs of the coefficients, thus: > 0 ; < 0

$$\left(\frac{\Delta Y}{Y}\right)_t - \alpha + \beta_1 \left(\frac{\Delta K}{K}\right)_t + \beta_2 \left(\frac{\Delta L}{L}\right)_t + \beta_3 \text{GEX}_t + \beta_4 \text{LITR}_t + \beta_5 \text{FDU}_t + \beta_6 \text{COMP}_t + \mu_t \dots \dots (4)$$

α is the intercept, μ is the error term β_1 and β_2 correspond to α and $1 - \alpha$ respectively in the growth accounting Equation (3) while the acronyms and other notations are as previously defined in connection with the growth accounting Equation (2) and productivity growth Equation (3).

The mathematical statement of the a priori expectation in connection with the productivity growth Equation (3) equally applies here while it also follows from the growth accounting Equation (2) that β_1 and β_2 are each supposed to be positive but less than unity.

A consequence of adopting this approach is that it is the effect of the climate factors on only the change in economy-wide productivity, $\left(\frac{\Delta A}{A}\right)$ (which is broadly defined to encompass miscellaneous factors of production that are not explicitly included as a part of K and N, improvement in the level of technology in the narrow sense of it, conduciveness to aggregate production of the macroeconomic, governance, political, social and other aspects of production environment in all its facets, including the external environment too) that are to be determined and not their effects, if any, on changes to quantities of labour (L) and capital (K).

3.3 Estimation Techniques

Both descriptive and inferential analyses are used in this present study. The descriptive analysis is carried out, using a descriptive statistics table that features, in respect of each variable, summary statistics of mean, median, standard deviation, minimum, and maximum values, among others. Also, in estimating the time

Substitution of the Productivity Growth (Equation into the Growth Accounting Equation to arrive at the Economic Growth Equation to estimate

To investigate the effect of climate change on economic growth, Equation (2) above is re-specified. This is done by substituting Equation (3) above into Equation (2) to now produce, after introducing the error term and intercept term α , the econometric model of economic growth that is in the form of Equation (4) below.

series data-based models, the study first tests for the presence of unit root in respect of each variable because of the generally non-stationary nature of time series data. In doing this, the study employs the use of Augmented Dickey unit root test. Following the outcome of the unit root test, the study proceeds to test for long-run relationship among the variables employed in the study using ARDL Bounds testing approach. Also, relevant diagnostic tests were conducted to determine the existence or otherwise of each of multicollinearity, heteroskedasticity, autocorrelation and non-normality in the distribution of regression residuals problem. ARDL method of estimation was adopted in estimating the long-run relationship that its existence has been confirmed by the ARDL Bounds cointegration test.

3.4 Nature and Sources of Data

The data for this study is time series, which is secondary in nature. All the datasets are yearly and they are collected from 1991 to 2022. The choice of 1991 as the commencement year was informed by the availability of data (that started from 1991) for most of the climate change components. The definitions of the variables employed in the study, their sources and how they are measured are as described below.

Nitrous oxide emissions (NOEM) are emissions from agricultural biomass burning, industrial activities, and livestock management. Concerning methane emissions (METEM), they are those emissions based on stemming from human activities such as agriculture and from industrial methane production. Regarding solid fuel emissions (CSOL), this is an emission from solid fuel consumption, referring

mainly to emission from the use of coal as an energy source. Concerning liquid fuel emissions (CLIQ), which is an emission from liquid fuel consumption that refers mainly to emissions from use of petroleum-derived fuels as an energy source? Coming to gaseous emissions (CGAS), these are the emissions from the use of natural gas as an energy source. Data on all the variables in this paragraph are sourced from the World Bank's World Development Indicators, WDI (2023), with all the variables being uniformly measured in thousand metric tons of CO₂ equivalent.

Regarding the control variables, foreign direct investment (FDI) is the net inflows of foreign direct investment that is expressed as percentage of GDP. Literacy rate (LITR) is the percentage of people aged 15 and above whom can both read and write with understanding a short simple statement about their everyday life. Government expenditure (GEX) is the purchase of goods and services by the government that is expressed as a percentage of GDP. Also, labor force growth () is the annual percentage change in labor force. In addition, private capital stock growth

() is the percentage change in real private capital stock. Finally, GDP is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products and its growth () refers to its annual percentage change. Data on all the dependent variable and all the above-named five control variables employed in this study were sourced from the World Bank's World Development Indicators, WDI (2023), with the exception of the private capital stock statistics that were obtained from International Monetary Fund Investment and Capital Stock dataset, IMF (2023).

4. Results and Discussions

4.1 Descriptive Statistics

This section presents and discusses the descriptive statistics for each of the variables employed in the study. The descriptive analysis provides an overview and summary of the salient characteristics of the data. Information about the mean, standard deviation, minimum and maximum is provided in the table to aid further understanding of the data.

Table 1: The Descriptive Statistics

Variables	Mean	Std. Dev.	Min	Max
GDP: Economic Growth, Annual percentage change in real GDP	4.26	2.68	0.10	10.60
LFG: Labour force growth	2.42	0.75	-1.62	2.76
PCS: Annual percentage change in real private capital stock	1.82	0.87	-1.51	3.22
LITR: Literacy level, % of people aged 15 and above who can both read and write.	57.62	4.37	51.08	70.20
FDI: Net foreign direct investment inflows, % of GDP	1.33	0.86	-0.04	2.90
GEX: Government expenditure, % of GDP	15.52	4.49	9.75	30.86
METEM: Methane emissions, measured in thousand metric tons of CO ₂ equivalent.	143667.30	8635.84	124198.20	157860.80
CSOL: Emissions from solid fuel consumption, measured in thousand metric tons of CO ₂ equivalent.	71.76	44.32	7.33	190.68
CGAS: Gaseous Emissions, measured in thousand metric tons of CO ₂ equivalent.	18492.13	7290.38	9127.16	32702.31
CLIQ: Petroleum emissions, measured in thousand metric tons of CO ₂ equivalent.	39189.04	13302.48	22255.02	70120.37
NOEM: Nitrous oxide emissions, measured in thousand metric tons of CO ₂ equivalent.	30116.66	6145.13	20595.24	41196.30
EMA: Aggregate Emissions (=METEM + CSOL + CGAS + CLIQ + NOEM) measured in thousand metric tons of CO ₂ equivalent.	46307.39	5171.29	38958.54	56083.84

Author's computation, (2023)

Explanatory Notes: Std Dev = standard deviation, Coeff of var = coefficient of variation, Min = minimum, max = maximum

As shown on table 1 above, the mean value for the variables employed which range from 1.33 to 46307.39 which were recorded by FDI and aggregate emissions respectively.

4.2 Unit Root Test Result

The result of the Augmented Dickey-Fuller unit root test is presented in Table 2. The study adopts a 5% statistical significance level as the cutoff, which means that it is only variables that have p-values of less than 0.05 that are adjudged to be stationary.

Table 2: Results of the Unit Root Test

Variables	Trace Statistic	P-value	Order of integration	Overall Decision
GDP	-2.8185	0.0673	I(0)	Unit root at level
	-6.9339	0.0000	-	
LFG	-3.5028	0.0147	I(0)	Stationary at level
	-	-	-	
PCS	-4.4972	0.0012	I(0)	Stationary at level
	-	-	-	
CGAS	-1.6204	0.4605	I(0)	Unit root at level
	-4.9304	0.0004	I(1)	
CSOL	-1.6699	0.4826	I(0)	Unit root at level
	-5.8923	0.0000	I(1)	
CLIQ	-2.0166	0.2786	I(0)	Unit root at level
	-6.3342	0.0000	I(1)	
METEM	-1.7323	0.4057	I(0)	Unit root at level
	-4.4984	0.0012	I(1)	
NEOM	-1.5839	0.4786	I(0)	Unit root at level
	-5.2559	0.0002	I(1)	
LITR	-1.7562	0.3462	I(0)	Unit root at level
	-4.4689	0.0014	I(1)	
FDI	-2.1466	0.2289	I(0)	Unit root at level
	-6.6318	0.0000	I(1)	
GEX	-2.2362	0.1983	I(0)	Unit root at level
	-7.68	0.0000	I(1)	
EMA	-1.6423	0.4493	I(0)	Unit root at level
	-5.8657	0.0000	I(1)	

Source: Author's Computation, 2024

Explanatory note: The following are the meanings of the acronyms appearing in the Table: Explanatory Notes: The following are the meanings of the acronyms appearing in the Table: = GDP growth rate, LFG= labour force growth, PCS = capital stock growth, CGAS = Carbon dioxide emission from natural gas, CLIQ = Carbon dioxide emission from petroleum, CSOL = Carbon dioxide emission from coal, METEM = Methane emissions from stemming, NOEM = Nitrous oxide emissions from burning and livestock management, LITR = Literacy rate, FDI = Foreign direct investment, GEX = Government expenditure.. The "p-value" stand for probability value.

Table 2 shows that and are stationary at level while all other variables employed are integrated of order one, i.e. they are all I (1), which means that the variables are not stationary at level but become stationary only when first-differenced. This implies that unit root exists in some of the variables but after first differencing, they became stationary. This is because at level the coefficients are not statistically significant at 5% adopted significance level. Since some variables are found to have unit root and some stationary at level, it is therefore necessary to test for existence of long-run relationship among all the variables employed by conducting cointegration test.

4.3 Cointegration Test

The ARDL Bounds cointegration testing approach is adopted because of the outcome of the unit root test conducted shows that variables appearing in each model have different integrating orders. The decision rule is to accept that the variables are cointegrated when the calculated F-statistic is greater than the

upper bound (I_1) value while the variables are adjudged not to be cointegrated if the computed F-statistic is less than the lower bound (I_0) and the

evidence is deemed inconclusive when the F-statistic falls in-between the upper and the lower bounds.

Table 3: ARDL Bound Testing Cointegration test

Models	F-Statistics	5% Critical Value		Remark
		I_0	I_1	
Model 1 that features methane emissions (METEM)	3.701	2.45	3.61	Co-integrated
Model 2 that features nitrous oxide emissions (NOEM)	3.924	2.45	3.61	Co-integrated
Model 3 that features solid fuel emissions (CSOL)	4.707	2.45	3.61	Co-integrated
Model 4 that features gaseous emissions (CGAS)	6.749	2.45	3.61	Co-integrated
Model 5 that features liquid fuel emissions (CLIQ)	4.802	2.45	3.61	Co-integrated
Model 6 that features aggregate emissions (EMA)	5.146	2.45	3.61	Co-integrated
Model 7 that features all the 5 individual emissions	5.046	2.06	3.24	Co-integrated

Source: Author's Computation, 2024

The results from Table 3 indicated that all the models are cointegrated. This is obvious from their respective F-statistics, which are all greater than the upper bound critical values. It is therefore appropriate to estimate the long-run relationship. Following from the existence of the long-run relationship among the variables, the ARDL method is used to estimate the models, with only the long-run estimates being reported, in view of the fact that short-run effects of the various explanatory variables on economic growth are not of primary interest to the study.

4.4 Presentation of the Estimates

The estimates of the 7 economic growth equations of the study are presented in Table 4. Each of the model estimate is organised and presented in 3 columns—one for the coefficients, another for the t-statistics and the 3rd for the p-values. The decision rule is that a p-value of not more than 5% means that the coefficient is statistically significant while a p-value that surpasses 5% means the coefficient is not statistically significant.

	Model 1			Model 2			Model 3			Model 4			Model 5			Model 6			Model 7		
	coeff	t-stat	p-value	coeff	t-stat	p-value	coeff	t-stat	p-value	coeff	t-stat	p-value	coeff	t-stat	p-value	coeff	t-stat	p-value	coeff	t-stat	p-value
LFG	0.387	0.60	0.558	3.545	2.57	0.024	1.722	2.47	0.027	7.847	3.39	0.002	4.507	3.67	0.003	4.864	3.99	0.002	0.369	0.54	0.596
PCS	0.429	0.66	0.520	30.167	2.45	0.026	7.146	1.14	0.274	47.67	3.67	0.004	18.637	2.57	0.024	19.901	2.95	0.011	16.540	2.20	0.046
LITR	0.005	0.05	0.964	0.094	0.33	0.748	0.207	3.19	0.007	0.744	4.16	0.002	0.427	2.68	0.020	0.591	3.19	0.007	0.019	0.12	0.904
FDI	0.624	0.75	0.462	2.498	1.53	0.144	1.617	2.20	0.045	4.012	2.50	0.030	1.290	1.34	0.205	2.004	2.40	0.032	1.313	1.18	0.259
GEX	-0.152	-0.83	0.419	-0.634	-1.93	0.072	-0.027	-0.24	0.816	-0.287	-2.20	0.050	-0.169	-0.98	0.344	-0.155	-0.99	0.339	-0.288	-1.06	0.310
METEM	-0.002	-2.36	0.031	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.004	-2.58	0.023
NOEM	-	-	-	-0.001	-0.50	0.627	-	-	-	-	-	-	-	-	-	-	-	-	-0.007	-0.37	0.717
CSOL	-	-	-	-	-	-	-0.003	-0.26	0.801	-	-	-	-	-	-	-	-	-	-0.020	-0.98	0.344
CGAS	-	-	-	-	-	-	-	-	-	-0.002	-2.25	0.046	-	-	-	-	-	-	-0.006	-0.35	0.729
CLIQ	-	-	-	-	-	-	-	-	-	-	-	-	-0.003	-2.53	0.022	-	-	-	-0.007	-0.90	0.386
EMA	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-0.002	-2.44	0.025	-	-	-
ECT (-1)	-0.815	-3.88	0.001	-0.511	-2.82	0.012	-1.115	-5.23	0.000	-0.859	-5.01	0.000	-1.021	-3.58	0.004	-0.869	-4.50	0.001	-0.596	-4.09	0.001
R-squared	0.67	-	-	0.72	-	-	0.86	-	-	0.90	-	-	0.80	-	-	0.82	-	-	0.88	-	-
No of obs	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32	32
VIF Test Statistics for Multicollinearity	2.29	-	-	1.61	-	-	1.65	-	-	1.63	-	-	1.56	-	-	2.25	-	-	3.68	-	-
Jarque-Bera Test Statistics for Normality	0.38	-	0.83	0.68	-	0.71	0.56	-	0.76	0.65	-	0.72	1.23	-	0.54	1.48	-	0.48	0.02	-	0.99
Woodridge Test	1.92	-	0.17	1.84	-	0.18	1.76	-	0.20	2.07	-	0.15	2.07	-	0.15	1.81	-	0.18	2.27	-	0.13

Statistics for Autocorrelation																					
Modified Wald-Test Statistics for Heteroscedasticity	0.51	-	0.79	0.51	-	0.79	0.55	-	0.77	0.29	-	0.94	0.73	-	0.63	0.54	-	0.77	0.30	-	0.97

Source: Author's Computation, 2024

Explanatory note: The following are the meanings of the acronyms appearing in the Table: Explanatory Notes: The following are the meanings of the acronyms appearing in the Table: = GDP growth rate, = labour force growth, = capital stock growth, CGAS = Carbon dioxide emission from natural gas, CLIQ = Carbon dioxide emission from petroleum, CSOL = Carbon dioxide emission from coal, METEM = Methane emissions from stemming, NOEM = Nitrous oxide emissions from burning and livestock management, LITR = Literacy rate, FDI = Foreign direct investment, GEX = Government expenditure, CEM = Emissions aggregate.. The “coeff”, and “p-value” stand for coefficients and probability value respectively

4.4.1 Evaluation of Performances of the Explanatory Variables

The coefficients of emissions from the use of natural gas as an energy source (CGAS) in Models 4 and 7 where it features are negative but statistically significant in only Model 4. This means that CGAS has a negative effect on economic growth in Nigeria. It is in line with the expectation posited in Section 3. Coming to the coefficients of emissions from the use of petroleum-derived fuels as an energy source (CLIQ) in Models 5 and 7, they are negative but statistically significant only Model 5. There is therefore evidence that CLIQ has a negative effect on economic growth and it is in line with the postulated negative effect stated in Section 3 of the paper. Regarding Models 3 and 7 which contains the emissions from the use of coal as an energy source (CSOL), the coefficients are negative but statistically insignificant in both equations. The impression conveyed by this evidence is therefore that CSOL no effect on economic growth. This is contrary to what was postulated in Section 3 of the paper. The coefficients of METEM, which is the emission that comes from stemming from human activities such as agriculture and from industrial methane production, are negative and statistically significant in both Models 1 and 7 where it appears. This means that METEM has a negative effect on economic growth and it is in accord with what was postulated in Section 3 of the paper. Also, NOEM, which is the emissions from agricultural biomass burning, industrial activities and livestock management, has negative but statistically insignificant coefficients in Models 2 and 7, which implies that there is no reliable evidence of negative effect of NOEM on economic growth. This is contrary to what has been posited in Section 3 of the paper. Regarding EMA, which is the composite or aggregate of the five categories of emissions discussed above, its coefficient, is negative and statistically significant, which means that the aggregate of these 5 individual emission categories collectively has a negative effect on economic growth? This is in line with what has been posited in Section 3 of the paper. As there has never been a previous study known to the present researcher that examined economic growth effects of any of the above 6 factors, it is inapplicable to compare the above findings.

Coming to the coefficients of labor force or , they are positive and statistically significant in 5 (viz: Models 2, 4, 5, 6 and 7) out of the 7 models but insignificant in the remaining 2 models so that an evidence that has a positive effect on economic growth. This conforms with the prediction of the growth accounting Equation (6) of Section 3 of the paper as well as findings from a number of previous studies, e.g. Nadilla & Ichsan (2023). Regarding the coefficients of private capital stock growth or in the 7 models, they are all positive but are statistically significant in only 5 (which are Models 2, 3, 4, 5 and 6). There is thus reliable evidence that has positive effect on economic growth and it is in line with the prediction of the growth accounting Equation (6) of Section 3 of the paper. There is no previous study known to the present researcher that examined economic growth effects of capital stock growth, it is inapplicable to compare the above findings. The coefficients of government expenditure (GEX) are all negative but statistically insignificant in all the 7 models. This means that there is no evidence that government expenditure has any effect on economic growth. This is in contrary to what was posited in Section 3 of this study and the findings reported by Onifade, Cevik and Erdogan (2020). Coming to literacy rate (LITR), its coefficients have the expected positive sign and statistically significant values in 4 out of the 7 models (viz: Models 3, 4, 5 and 6) but insignificant in Models 1, 2 and 7. There is therefore some evidence that LITR has a positive effect on economic growth. This is in line with what was discussed in Section 3 of the paper and the findings by Barro & Lee (2013), Cohen & Soto (2007), Barro(1991), Mankiw, Romer and Weil (1992). Finally, regarding the effect of foreign direct investment (FDI) on economic growth, its coefficients are positive in all the 7 cases but are statistically significant in only 3 (viz: Models 3, 4 and 6). This means that there is some evidence that FDI has a positive effect on economic growth in Nigeria. This finding is in line with what was earlier posited in Section 3 of the paper and what had also been reported by Duarte, Kedong and Xuemei (2017) and Maheswaranathan and Jeewanthi (2021), among others.

5. Conclusion and Recommendations

The problem at hand is understanding the specific ways in which climate change affects Nigeria's economy and how these affects or influence economic growth. By identifying the key challenges and potential opportunities with these different manifestations of climate change factors, policymakers and stakeholders can develop effective strategies to mitigate the negative effects of climate change on the economy as a means to fostering sustainable growth. The study therefore examined the effect of climate change on economic growth in Nigeria. Concerning the methodology of achieving the above stated objective of the paper, the study employed the growth accounting equation framework that is, in turn, an offshoot of the neoclassical growth theory and this served as the bedrock of the theoretical framework on which the models of this study were constructed. The dependent variable is GDP growth while the independent variables are the various measures of climate change and their aggregate. Also featuring as explanatory variables are 5 control variables, which are labor force growth, private capital stock growth, foreign direct investment, literacy rate and government expenditure. Following from this, a set of seven equations were specified to examine the effects of the explanatory variables on economic growth, with one of the 5 measures of climate change and its composite being made to feature, one at a time, in the models, with all of the 5 categories being made to feature simultaneously in the seventh equation for the sake of comparison.

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The stationarity of the data were tested with the use of Augmented Dickey Fuller (ADF) unit root test and the cointegration of the models was examined through the ARDL bounds testing approach. Based on these outcomes, the ARDL long-run estimation technique was adopted to derive the long-run estimates of the models that were reported and evaluated in the paper. The study used annual time series data for Nigeria from 1991 – 2022 that were all sourced from the World's Bank World Development Indicators (WDI) and International Monetary Fund Investment and Capital Stock dataset (IMF).

Following the completion of the above test, the finding shows that methane emissions, emissions from the use of gas, liquid fuel emissions, and composite emissions have negative effects on economic growth while 4 control variables are all found to have the expected positive effects on economic growth. On the other hand, it was also found that nitrous oxide emissions, solid fuel emissions and government expenditure were also found not to record any effect on the growth of output in Nigeria. Generally, it can be concluded that climate change has negative effect on economic growth and this negative effect came through its negative effect on methane emissions, gaseous emissions, liquid emissions and aggregate emissions. The study therefore recommends that if climate change is mitigated by reducing the consumption of those components that were found to have negative effects, it will increase economic growth in Nigeria.

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