CLIMATE CHANGE AND ECONOMY IN NIGERIA: A QUANTITATIVE APPROACH

1 Adejumo Musibau Ojo, University of Lagos, Department of Economics, Nigeria
*Corresponding author e-mail: adejumoeco@gmail.com
1 ORCID ID: 0000-0002-0092-4794

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ABSTRACT

This study has examined the potential impacts of climate change on Nigerian economic growth using a time series data (1980-2017). In doing so, an econometric model has been constructed based on theoretical and empirical literatures of the climate change economics, then it has employed a growth model adapted from the Solow growth model. The research work found that annual average rainfall has a significant effect on economic growth both short-run and long-run. Also, there is a high degree of positive and significant relationship between carbon emission, foreign direct investment, gross fixed capital formation and economic growth under investigation. The result also revealed that this relationship between climatic factors and economic growth is more noticeable in the long run. In addition, an inverse relationship was found between forest depletion, population growth and economic growth in the long run. Finally, there is unidirectional causality between annual average rainfall and economic growth in Nigeria. It is therefore recommended that the stakeholders and the general public should build green economy that enables sinking carbon and promotes carbon market in the long-run.

1. INTRODUCTION

Climate change poses a major threat to poverty reduction and sustainable development worldwide, especially in developed countries (Nigeria inclusive). Nigeria has a vast population that is directly dependent on climate-sensitive economic and development sectors (agriculture and fisheries) as well as natural resources (such as water, biodiversity, and grassland) for sustenance and subsistence (Fadairo et al., 2020). Furthermore, the rural majority's adaptation ability to climate change impacts is very limited. Unfortunately, several of the country's new growth plans seem to underestimate climate change threats. The risks of failing

to mitigate climate change or respond to it remain unknown, but the welfare implications are likely to be immense (Stiglitz, 2019).

Nigerians live on the front lines of pollution, disaster, and degradation of resources and land. Unfortunately, despite growing concern, no precise and reliable figures are available to measure the economic costs of negative impacts of climate change in Nigeria for individuals or society as a whole. As far as development is concerned, climate change has had a significant effect on Nigeria's ability to achieve overall economic growth and sustainability, putting additional strain on agriculture, water supply and demand, health, and political stability. (Ikhuoso et al., 2020). Climate change is today being recast as a security threat, rather than being just an environmental issue. Increasing energy consumption contributes to global warming. The economies face a host of environmental problems as a result of climate change which have a greater impact on their economic well-being. The nation is marked by a brutal cycle of poverty, desert encroachment, flood, and CO2 emissions that have caused extensive harm to homes and facilities, displaced hundreds of families, and resulted in significant livestock losses and food insecurity.

The empirical evidence on this debate is of much relevance to growth and environmental policies in the developing world, more so in Sub-Sahara Africa (SSA) where income levels are below acceptable standards. Ensuring sustained long-run growth and environmental sustainability requires prior establishment of the nexus between economic growth and climate change. Recent attention has shifted to the pair-wise nexuses between climate change and economic growth, economic growth and emissions, and emissions and climate change. However, a huge gap remains, particularly, in the empirical link between economic growth and climate change. This study looks at the effect of climate change on sustainable growth in Nigeria using time series cointegration modelling techniques. The study explores and analyzes the effects of climate change on economic growth. None of the previous studies had considered the problem of endogeneity facing time series data. The novelty of the empirical contribution is that the study employs Autoregressive Distributive Lag (ARDL) method of estimation. This Method is superior because it accommodates the problems of autocorrelation and heteroskedasticity that may exist among the variables employed and their residual.

Finding of the study will provide useful insights for policymakers and academics into climate change risk. For policymakers in Nigeria, this work becomes important because it provides empirical evidence to support the provision of adaptation efforts to moderate the impact of climate change which could affect shared growth. Therefore, the empirical verification of the moderating role of adaptive

capacity to climate change impact on economic growth is critical. The outcome of the study will lend support to the pursuit of adaptation strategies to be based more on evidence than guesswork. For academia, this research adds to literature by granting the academic community a better insight into the link between climate change and economic growth as well as open up discussion in this light that provokes thoughts and ideas to support Nigeria's economic growth agenda.

This study is structured into four sections: section one covered the introductory part, section two addressed the materials and method, section three covered the empirical results of the findings, while section four detailed conclusion and recommendations.

2. MATERIALS AND METHODS

2.1. Theoretical model

To analyze the impacts of climate change on economic growth two types of approaches are most widely used, that is, enumerative approach and dynamic approach. In the enumerative approach the economic impacts of climate change are analyzed separately sector by sector, that is, impacts of climate change on agriculture, ecosystem tourism, etc. Later these effects are added up to obtain an estimate of total change in the social welfare from climate change **(**Ahmed, 2020). In this approach, ARDL models and simulation techniques are mostly used.

In dynamic approach, different specifications of growth models are used by incorporating climate change indicators into growth models. Liu, Huang and Yang, (2020), Khan, Yu, Sharif and Golpîra (2020) are most widely used growth models to analyze the impacts of climate change on economic growth. In these models the impacts of climate change are directly linked to GDP.

The present study will use both of these approaches to some extent and analyze the impacts of climate change on economic growth and its components, that is, agriculture, manufacturing and services. Guntukula and Goyari, (2020) incorporated climate change in the production function, and this model will be used as baseline in the present study because it provides theoretical basis for incorporating climate change into economic growth equations. Consider the production function.

$$Y_t = e^{\alpha T_t}, A_t, L_t, K_t \tag{1}$$

$$\frac{\Delta A_t}{A_t} = \beta T_t \tag{2}$$

Where Y is GDP, L is labor force, A is technology and can also be referred as a labor productivity, and T is the impacts of climate and K is physical capital. Equation (1) captures direct effects of climate change on economic growth. While equation (2) captures the indirect effect of climate, that is, the impact of climate on other variables that indirectly influence the GDP growth. It is worth mentioning here that the equation (1) directly relates climate change to GDP whereas in the equation (2) climate changes affect labour productivity that will affect the GDP growth. After taking logs of equation (1) and differencing with respect to time, the following equation can be derived.

$$g_t = (\alpha + \beta) T_t - \alpha T_{t-1} \tag{3}$$

Where gt is the growth rate of GDP, direct effects of climate change on economic growth appear through α and indirect effects appear through β. This equation separately identifies the direct and indirect effects of climate change. Both of these affect GDP growth rate in the initial period. However, when climate returns to its prior state then direct effect reverses itself. For example, a rise in temperature may harm agricultural production, but whenever temperature returns to its normal level the agricultural production once again accelerates. On the other hand, indirect effect emerges during the climatic shock and their impact persists even in the normal conditions: for example, a failure in human capital development results in a permanent deterioration in human capital and economic growth.

2.2. Model Specification and Data Availability

The study used secondary time series dataset which poses some challenges. The presence of non-stationary macroeconomic variable and variables with long time dimension subject the regression to spurious results and according to Castle, Doornik and Hendry, (2020), the presence of non-stationary variables abounds. The presence of non-stationarity makes forecasting and predicting difficult. The extension of time series data helps deal with issues of non-stationarity and cointegration Castle, Doornik and Hendry, (2020). In the analysis for cointegration, the study checked for unit root and cointegration and then estimated the long run and short run relationship.

The data is fitted to an autoregressive model on the premise that (i) the current values of the dependent variable could depend on a linear combination of its past values as well as (ii) the past values are distributed across time in the past. Following from the aforementioned, the study therefore uses Autoregressive Distributed Lag model which allows the study to include the lagged values of both the dependent (GDPgr) and independent variable(s) (C02, FRD, AAR,

FDI, GFCF, POP). The ARDL model allows for flexibility which makes it possible to use variables integrated of different order except for 1(2) (Pata and Aydin, (2020)). Autoregressive Distributed Lag (ARDL) models:

$$GDPgr_t = \beta_0 + \beta_1 GDPgr_{t-1} + \beta_2 C02_{t-1} + \beta_3 FDI_{t-1} + \beta_4 GFCF_{t-1} + \beta_5 POP_{t-1} + \sum_{j=1}^{q} \gamma_1 GDPgr_t + \sum_{j=1}^{p} \gamma_2 C02_t + \sum_{j=1}^{p} \gamma_3 FDI_t + \sum_{j=1}^{p} \gamma_4 GFCF_t + \sum_{j=1}^{p} \gamma_5 POP_t + \alpha_t + \varepsilon_t \quad (4)$$

$$GDPgr_t = \beta_0 + \beta_1 GDPgr_{t-1} + \beta_2 FRD_{t-1} + \beta_3 FDI_{t-1} + \beta_4 GFCF_{t-1} + \beta_5 POP_{t-1} + \sum_{j=1}^{q} \gamma_1 GDPgr_t + \sum_{j=1}^{p} \gamma_2 FRD_t + \sum_{j=1}^{p} \gamma_3 FDI_t + \sum_{j=1}^{p} \gamma_4 GFCF_t + \sum_{j=1}^{p} \gamma_5 POP_t + \alpha_t + \varepsilon_t \quad (5)$$

$$GDPgr_t = \beta_0 + \beta_1 GDPgr_{t-1} + \beta_2 AAR_{t-1} + \beta_3 FDI_{t-1} + \beta_4 GFCF_{t-1} + \beta_5 POP_{t-1} + \sum_{j=1}^{q} \gamma_1 GDPgr_t + \sum_{j=1}^{p} \gamma_2 AAR_t + \sum_{j=1}^{p} \gamma_3 FDI_t + \sum_{j=1}^{p} \gamma_4 GFCF_t + \sum_{j=1}^{p} \gamma_5 POP_t + \alpha_t + \varepsilon_t \quad (6)$$

$GDPgr_t$ is the dependent variable denoting economic growth that captures key indicators. The explanatory variable C02, FRD and AAR represent climate change measured by CO2 emissions for meteorological a year, Forest Depletion and Average Total Annual Rainfall respectively. The following are control variables that have the potential of augmenting growth: FDI is the foreign direct investment measured by FDI inflows as a percentage of GDP; GFCF is the gross capital formation which captures investment; POP is the population outcome measured by the population of age 15-64 as a percentage of total population; α_t is time fixed effects and ε_t is the disturbance term of the equation.

Data is sourced for the study from the World Development Indicators (WDI), Food and Agriculture Organization (FAO). The data collected are annual data for a 27 year period from 1990 to 2017 for Nigeria. Data from these sources are combined to carry out this study.

This study adopts Autoregressive Distributed Lag (ARDL) regression method to analyze the impact of climate change on economic growth. In the process of analyzing the data to test the research hypotheses and draw valid conclusion, the

model regresses the dependent variable (Gross Domestic Product growth rate) on the independent variables (C02, FRD, AAR, FDI, GFCF, POP).

3. RESULTS AND DISCUSSIONS

The primary aim of this research is to empirically examine the association between economic growth and climate change in Nigeria, and thus provide some illuminating data on the validity of the Environmental Kuznets Curve (EKC) hypothesis. As is conventional in empirical studies such as this one, some data evaluation and testing analysis will be pertinent in order to ensure that the empirical estimates obtained in this way are empirically valid and reliable. Hence, as earlier stated in this section, the first test exercise is the unit root test analysis which is presented in Table 1 below:

3.1. Unit Root Test Results

The unit root test methods utilized for the purpose of evaluating the stationarity property of the series employed for this study are those that have been widely employed in empirical analysis such as ours. Specifically, Augmented Dickey Fuller (ADF) and Phillip Perron (PP) are the basic criteria that have been used in this study because of their widespread application in previous empirical studies. The result of the unit root test based on the ADF and the PP methods is presented in Table 1 below:

Table 1. Unit Root Test Results

Variables	Augmented Dickey-Fuller (ADF) Test		Phillip Perron (PP) Test		Conclusion on the Order of Integration	
	Levels	1st Diff.	Levels	1st Diff.	Levels I(0)	1st Diff. I(1)
GDPGR	-4.610936 (0.0007)	-6.773221 (0.0000)	-4.618533 (0.0007)	-18.93011 (0.0001)	Yes	Yes
CO2	-1.402121 (0.5708)	-6.043997 (0.0000)	-1.402121 (0.5708)	-6.049457 (0.0000)	No	Yes
FRD	-2.021680 (0.2766)	-8.762324 (0.0000)	-2.625393 (0.0971)	-8.762324 (0.0000)	No	Yes
AAR	-1.628193 (0.4585)	-6.168916 (0.0000)	-1.613470 (0.4658)	-6.189276 (0.0000)	No	Yes
FDI	-3.667886 (0.0089)	-8.417580 (0.0000)	-3.635817 (0.0096)	-13.76205 (0.0000)	Yes	Yes
POP	-3.039933 (0.0406)	-8.009122 (0.0000)	-3.655226 (0.0092)	-4.329672 (0.0016)	Yes	Yes
GFCF	-5.086443 (0.0002)	-9.928455 (0.0000)	-5.062003 (0.0002)	-10.14736 (0.0000)	Yes	Yes

Source: Author's computation (2021).

The unit root test is carried out with constant and trend specifications for the respective series. The lag-selection was based on the default selection of the Akaike-Information Criterion (AIC). The table contains the ADF and the PP test statistic at levels and first difference of the time series. The numbers in the brackets represent the probability values of the estimate test statistic of the ADF and PP tests.

The unit root test result from the ADF and PP methods shows that the order of integrations mixed with some of the variables being stationary at levels and first difference at the same time. In particular the stationarity of the general unit root process for the set of time series data for the variables shows that they are all significant at least at the 5 percent level for the first difference of all variables and thus the null hypothesis of unit root in the data cannot be upheld.

3.2. Lag Selection Criteria Result

In view of the unit root test result, some empirical investigation on the Lag selection of the model can be examined. The output of the result will assist to determine the best lag selection for the model. The intuition behind this is that the criteria that produce the minimum value is the best lag for the model.

Table 2. Model Selection Criteria Table

VAR Lag Order Selection Criteria
Endogenous variables: GDPGR
Exogenous variables: C CO2 FRD AAR FDI GFCF POP
Date: 01/18/21 Time: 20:53
Sample: 1980 2017
Included observations: 35

Lag	LogL	LR	FPE	AIC	SC	HQ
0	-112.0523	NA*	53.01520*	6.802991*	7.114060*	6.910372*
1	-111.9195	0.204975	55.86205	6.852542	7.208050	6.975263
2	-111.4625	0.678957	57.82963	6.883571	7.283518	7.021633
3	-111.0542	0.583259	60.09127	6.917383	7.361769	7.070785

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

Source: Author's computation (2021).

The results of the test for the respective equation specifications are contained in Table 2 above. As evident from Table 2, three criteria were examined for the models (Akaike info criterion (AIC), Schwarz criterion (SC) and Hannan-Quinn criterion (HQ). By simple examining the result of the lag selection between three criteria, it is clearly shown that Akaike Info Criterion produced the minimum values and it is significant at lag zero through the model selection. Hence AIC lag zero will be used throughout the period of investigation in this study.

3.3. ARDL Bound Test

In view of the unit root test result, some empirical investigation on the long-run relationship in the model can be examined. Though the unit root test does not strictly satisfy the condition for embarking on a Bound Test, doing this will help establish if any of the sets of variables may be cointegrated. The most prominent and widely used technique for ARDL model in the literature has been that developed by Pesarant (2011) as cited by Dhungel, (2012)

Table 3. ARDL Bound Test Result

ARDL Bounds Test
Date: 01/18/21 Time: 22:04
Sample: 1981 2017
Included observations: 37
Null hypothesis: No long-run relationships exist

Test Statistic	Value	K
F-statistic	7.873040	6
Critical Value Bounds		
Significance	I0 Bound	I1 Bound
10%	2.12	3.23
5%	2.45	3.61
2.5%	2.75	3.99
1%	3.15	4.43

Source: Author's computation (2021).

From the result, the F statistic value is greater than the bound values at different significance levels. Hence, we reject the null hypothesis of no cointegration among variables in the long run. With this result, Error Correction Model will be employed for general estimation of this model.

3.4. Serial Correlation Test

Table 4. Breusch-Godfrey Serial Correlation LM Test

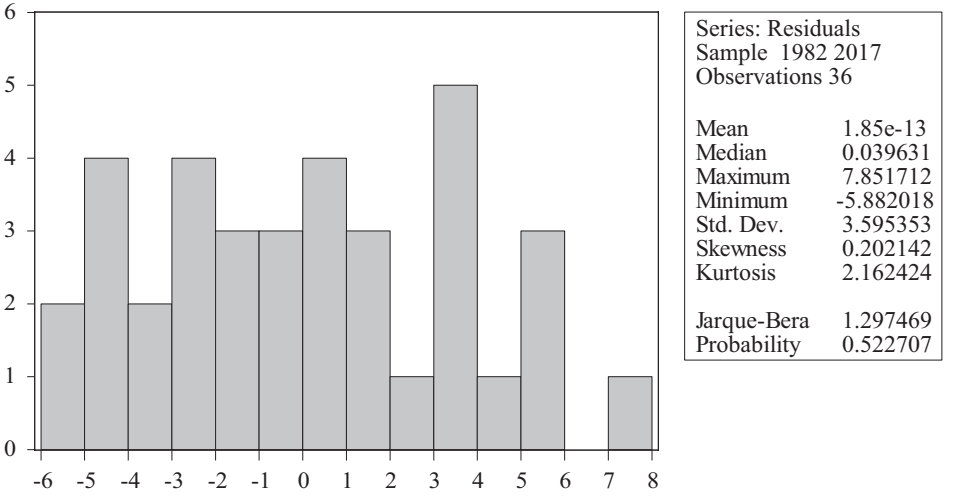
Breusch-Godfrey Serial Correlation LM Test:			
F-statistic	2.689177	Prob. F(2,24)	0.0883
Obs*R-squared	6.773664	Prob. Chi-Square(2)	0.0338

Source: Author's computation (2021).

The result revealed that the model is free from the problem of serial correlation since F statistic probability is greater than 5% level of significance.

3.5. Normality Test

Figure 1. Normality Test of the Model



Source: Author's computation (2021)

The figure 1 above depicts the normality of the model over the period of investigation. From the result, the model mean value is 1.85, jarque Bera value of 1.297469 with probability value of 0.522707. The null hypothesis states that the model is normally distributed. From the result, the probability value is greater than 5% level of significance, hence we fail to reject null hypothesis. Therefore, we conclude that the model is normally distributed over the period of investigation.

3.6. Stability Test

Before proceeding to ARDL estimation, the study has to verify the model's stability, which is checked by Ramsey Reset test. The results confirm stability of the model at 5% significance level.

Table 5. Stability Test

Ramsey RESET Test
Equation: UNTITLED
Specification: GDPGR GDPGR(-1) CO2 CO2(-1) CO2(-2) FRD FRD(-1) FRD(-2) AAR AAR(-1) AAR(-2) FDI GFCF GFCF(-1) POP POP(-1) POP(-2) C
Omitted variables: Squares of fitted values

	Value	Df	Probability
t-statistic	1.582400	18	0.1310
F-statistic	2.503990	(1, 18)	0.1310
F-test summary:			
	Sum of Sq.	Df	Mean Squares
Test SSR	55.25165	1	55.25165
Restricted SSR	452.4297	19	23.81209
Unrestricted SSR	397.1781	18	22.06545

Source: Author's computation (2021)

The stability of the model was examined. The result revealed that the null hypothesis of no stability was rejected since the probability of F statistic was greater than 5% level of significance. Hence, we conclude that the model is stable.

3.7. Heteroscedasticity Test

One of the unlined assumptions of linear regression is constant variance of the model (Homoscedasticity) violation of this assumption can lead to bias estimation of the model parameters. To validate this assumption, this study checked the heteroscedasticity of the model using the Breusch-Pagan-Godfrey approach and the result is presented below:

Table 6. Heteroscedasticity Test

Heteroskedasticity Test: Breusch-Pagan-Godfrey			
F-statistic	1.944270	Prob. F(16,19)	0.0838
Obs*R-squared	22.34957	Prob. Chi-Square(16)	0.1323
Scaled explained SS	3.618313	Prob. Chi-Square(16)	0.9994

Source: Author's computation (2021)

From the result, the F statistic value of 1.944270 and probability value of 0.0838 shows that the null hypothesis of no heteroscedasticity cannot be rejected since the probability value of 0.0838 is greater than 5% level of significance. Hence, the assumption of constant variance is valid for the model.

3.8. Parsimonious Error Correction Estimates

Having established the fact that some of the explanatory variables in the model do have long-run relationship with the dependent variable it would be relevant also to examine the direction of and magnitude impact of the relationship between private consumption and the set of explanatory variables captured in the model. In this sense the aim is to obtain empirical estimates measuring the impact of regressors on the dependent variable.

For this purpose the Autoregressive Distributed Lag (ARDL) is employed for the estimation. The ARDL is a long-run parameter estimation method in which the steady state converging relationship can be evaluated and examined based on the parameter estimates obtained from the estimation exercise.

The result of the regression analysis is shown in Table 7 below. The table contains the parameter estimates obtained from the ARDL estimation approach. The variables are estimated in their growth form for purpose of data demeaning and to avoid outliers which can lead to heteroscedasticity problems.

In the table the values in the brackets are the probability values of the parameter estimates of the model. The last two columns to the right show the conclusion on the sign and test of significance of the parameter estimates of the variables. The negative or positive sign indicates negative or positive impacts of the explanatory variable on the dependent variable respectively. The significance of the estimated coefficients is tested from the probability value of the estimated coefficients. If the probability value of the estimated coefficient is less than 5 percent then the explanatory variable has a significant impact on the dependent variable. Hence the research hypothesis cannot be upheld.

The above result depicts the long run and short run equations of the model. From the result in the short run, it shows that climate change has a significant impact on economic growth.

In the long run, carbon emission (C02) has a significant positive relation with private economic growth. Only 1% point increase in carbon emission (C02) leads to 16.42% increase in economic growth in Nigeria. This result does not conform to prior expectation and this could be as a result of over reliance on the use of fossil fuel for productive activities. It is quite cleared that carbon emission is not an important determinants of economic growth in the long run.

Table 7. Parsimonious Error Correction Estimates

Dependent Variable: GDPGR
Method: Least Squares
Date: 01/17/21 Time: 03:31
Sample (adjusted): 1981 2017
Included observations: 37 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	38.79219	0.909986	42.62943	0.0000
CO2	16.42091	0.159115	103.2014	0.0000
FRD	-1.000193	0.022967	-43.54903	0.0000
AAR	2.447295	0.009802	249.6608	0.0000
FDI	0.109104	0.010010	10.89965	0.0000
GFCF	0.005914	0.000778	7.599790	0.0000
POP	-25.24830	0.340449	-74.16167	0.0000
ECM	1.000000	0.002612	382.9039	0.0000
R-squared	0.999874	Mean dependent var.		3.451011
Adjusted R-squared	0.999843	S.D. dependent var.		7.519255
S.E. of regression	0.094216	Akaike info criterion		-1.697641
Sum squared resid.	0.257424	Schwarz criterion		-1.349334
Log likelihood	39.40635	Hannan-Quinn criter.		-1.574846
F-statistic	32752.83	Durbin-Watson stat		1.903131
Prob(F-statistic)	0.000000			

Source: Author's computation (2021).

Forest depletion (FRD) has a significant negative relation with economic growth in the long run. The result also conforms to prior expectation. However, 1% point increase in forest depletion will lead to 1.00% decrease in economic growth. Hence, it becomes clear that forest depletion in an important variable determining economic growth in the long run.

Annual average rainfall is also an important determinant of economic growth in Nigeria. From the result, 1% increase in annual average rainfall will lead to about 2.45% increase in economic growth. The result also conforms to prior expectation and it is significant at 5% level of significance. Hence, it becomes clear that annual average rainfall is an important determinant. This result depicts that Nigerian relied on annual rainfall for her endowed agricultural activities since the sector accounting for more than 60% of her GDP.

Foreign direct investment that captured the foreign investment in the economy depicts a direct relationship with economic growth. From the result, 1% increase in foreign direct investment (FDI) will lead to about 0.11% increase in economic growth and such relation is significant in the long run.

Gross Fixed Capital Formation (GCFC) and population growth (POP) show that they are important determinants affecting economic growth in the long run. From the result, 1% point increase in capital formation will lead to about 0.06 % increase in economic growth. Also, population depicts an inverse relation with economic growth and the impact is significant at that period of investigation. Hence, this result justifies the reality of Malthusian Theory of Population in Nigeria. The R^2 statistics shows that explanatory variables accounted for 99% variation of economic growth in the long run. This is supported by higher adjusted R^2 value of 99%. Also, the Durbin Waston Statistics value of 1.903131 falls within the rejection region of absence of serial correlation among the regressors.

The Akaike info criterion, Schwarz criterion and Hannan-Quinn criterion value of -1.697641, -1.349334 and -1.579846 respectively indicate that the model selection is good.

3.9. Causality Test

Having established the magnitude of the impact of the set of explanatory variables that entered the regression equation the study proceeds further to investigate nature of causality among the variables paying particular attention to the causality of the government expenditure variable and private consumption. The causality test is carried out using the growth rate of the variables, using the one lag-length as stipulated by the Akaike Information Criteria (AIC). The test method is the Stacked test method with common coefficients. The hypothesis testing procedure follows similar procedures as stated in order aspects in this study. The result of the causality test is contained in Table 8. The arrows in between the variables indicate the hypothesized direction of causality while the asterisks *** and ** denote the asymptotic significance of the F-test statistic.

Table 8. Causality Test

Direction of Causality	Null Hypothesis (H_0)	F-statistic	P-values	Decision
GDPGR→AAR	No Causality	1.37994	0.2483	Do not Reject H_0
AAR→GDPGR	No Causality	7.27563**	0.0108	Reject H_0
GDPGR→FRD	No Causality	1.26799	0.2680	Do not Reject H_0
FRD→GDPGR	No Causality	0.05941	0.8089	Do not Reject H_0
GDPGR→CO2	No Causality	1.82496	0.1856	Do not Reject H_0
CO2→GDPGR	No Causality	0.03079	0.8617	Do not Reject H_0

Source: Author's computation (2021).

The result of the granger causality test indicates that the null hypothesis can only be rejected in three causality relations. Specifically, the result shows that only annual average rainfall has a strong causality relationship with economic growth and hence its null hypothesis cannot be upheld. Though there is causality between these variables, the direction of causality only flows from this variable to economic growth. Given this outcome, it can be said that there is a unidirectional causality between annual average rainfall to economic growth.

The result from the causality test most adequately, lends credence to the validity of the regression earlier obtained from the ARDL regression exercise. It provides robust evidence linking the climate change and economic growth

The study found that annual average rainfall has a significant effect on economic growth in both short run and the long run.

Also, there is a high degree of positive and significant relationship between carbon emission, foreign direct investment, gross fixed capital formation and economic growth under investigation. The result also revealed that this relationship between climatic factors and economic growth is more noticeable in the long run.

In addition, an inverse relationship was found between forest depletion, population growth and economic growth in the long run.

Finally, there is unidirectional causality between annual average rainfall and private economic growth in Nigeria.

3.10. Comparison of Result with Previous Studies

The outcome of this study revealed that annual average rainfall, forest depletion and carbon emission proxy for climate change have significant effect on economic growth both in the short run and in the long run.

In the long run, the empirical results obtained from this study show some interesting empirical regularities and resemblance with previous studies. Specifically, the results here in some aspects support the results of previous studies on this topic, for example, forest depletion has negative impact on growth likewise population growth, while carbon emission, annual rainfall depicted a direct relationship with growth. This finding contradict the findings of Belford et al. (2020) whose results revealed negative impact on growth in Gambia. Recent empirical studies in this strand of the literature have noted that the climate change is an important determinant influencing economic growth in Nigeria. This result is in line with the findings of Alagidede, Adu and Frimpong, (2016) and Abidoye and

Odusola, (2015) whose findings revealed that climate change has a significant impact on economic growth. In this regard, the result derived from the ARDL estimation confirms this assertion.

4. CONCLUSION AND RECOMMENDATIONS

4.1. Conclusion

This study has examined the potential impacts of climate change on Nigerian economic growth using a time series data (1980-2017). In doing so, an econometric model has been constructed based on theoretical and empirical literature on the economics of climate change, then it has employed a growth model adapted from the Solow growth model. Accordingly, the result shows that an increase in forest depletion has a negative impact on economic growth measured by growth rate of gross domestic product. On the other hand, since Nigeria depends on rain-fed agriculture which comprises a huge share of GDP, a decline in rain fall reduces an economic growth. The reduction in economic growth will also result in increasing poverty. Thus, the control of climate change is not only important for economic growth problem, but also crucial for poverty alleviation. The result asserts that if climate change is not controlled, the economic growth will be reduced (an increase in forest depletion dangers a lot) considerably in the long run. However, Nigeria alone can do very little with regard to controlling climate change as its share of greenhouse gas emissions in comparison to developed countries is small. Although developing countries like Nigeria contribute least to causing climate change, they are most affected by this phenomenon. This is due to their dependency on agriculture and their inability to pay for the resources necessary to combat climate change via adopting the preventive measures (mitigation) and adaptation techniques.

4.2. Recommendations

As a result of the outcome of this study, the following policy recommendations were suggested:

Since Nigeria is experiencing the effects of climate change, it requires an active step in managing or controlling climate-related problems. In order to solve this negative externality, the mitigation (ex-ante) and adaptation (ex-post) strategies should be in place. Besides the direct effects such as an increase in average temperature or a short run dynamics in rainfall patterns, climate change also presents the necessity and opportunity to change to a new, sustainable develop-

ment model, Climate-Resilient Green Economy (CRGE) Strategy to protect the country from the adverse effects of climate change and to build a green economy. Furthermore, Nigeria should firmly continue with the bargaining and active participation in the climate change agreements at the global scale so as to be compensated for the risk of greenhouse gases emitted from industrialized countries which take historical responsibility for emission. In response to the severe impacts of climate change on economic growth some possible climate-related strategies or programs and policies should be implemented. Since climate change has already begun in our country, mitigation to reduce its damage should be applied primarily. Then, adaptation should be the second and best method to reduce the adverse impact of climate change since adjustment is an important tool for the long-run economic growth. In line with these programs, government should apply policies related to climate change with objectives to minimize the emissions of greenhouse gases by using alternative energy sources such as geothermal energy, hydrothermal energy and solar energy. Furthermore, building a strong green economy should be a part and parcel of all stakeholders and the general public. This building of green economy enables sinking carbon and promotes carbon market in the long-run.

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КЛИМАТСКЕ ПРОМЈЕНЕ И ЕКОНОМИЈА НИГЕРИЈЕ: КВАНТИТАТИВНИ ПРИСТУП

[1] Адејумо Мусибау Ојо, Универзитет у Лагосу, Економски факултет, Нигерија

САЖЕТАК

Ова студија је испитала потенцијалне утицаје климатских промјена на нигеријски економски раст користећи податке из временских серија (1980-2017). Стога је изграђен економетријски модел, заснован на теоријским и емпиријским радовима економије климатских промјена, а затим је примијењен модел прилагођен Соловљевом моделу раста. Истраживање је објелоданило да просјечне годишње кише имају значајан ефекат на економски раст у кратком и у дугорочном периоду. Такође, постоји висок степен позитивне и значајне везе између емисије угљеника, страних директних инвестиција, формирања бруто трајног капитала и економског раста. Резултат је такође открио да је овај однос између климатских фактора и економског раста уочљивији у дуго року. Поред тога, пронађена је обрнута веза између исцрпљености шума, раста становништва и економског раста на дужи рок. Коначно, постоји једносмјерна узрочност између просјечних годишњих

киша и економског раста у Нигерији. Стога се препоручује да заинтересоване стране и шира јавност треба да граде зелену економију која омогућава смањење нивоа угљен-диоксида и дугорочно промовише тржиште угљеника.

Кључне ријечи: *економски раст, глобално загријавање, угљен-диоксид, климатске промјене.*