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Original Article

The Effect of Natural Gas Utilization and CO_2 Emissions on the Economic Growth of Nigeria

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Abstract *- The paper examines the causality and co-integration relationship between natural gas utilization, CO_2 per capita emissions, and economic growth in Nigeria from 1981 to 2015 using the granger causality technique and autoregressive distributive lag (ARDL) approach. Granger causality test results show the bi-directional casualty between GDP per capita and CO_2 emissions. Also, casualty between natural gas utilization and GDP per capita is bi-directional. However, causality for natural gas utilization and CO_2 emissions is unidirectional, where natural gas causes CO_2 emissions. The co-integration test suggests a long-run relationship among natural gas utilization, CO_2 emissions, and GDP per capita. We find that for both the long-run and short-run ARDL model decrease in CO_2 emissions will encourage economic growth. In the shortrun, an increase in natural gas utilization supports economic growth.*

Keywords *- CO2, Natural Gas, GDP per capita, Causality, ARDL.*

I. INTRODUCTION

A growing concern of global warming and climate change has given rise to several recent debates, especially in the field of oil and gas, energy economics, environmental science, oceanography, climatology, and many more. Human activities, energy utilization, industrialization have continuously led to the increase of greenhouse emissions. Countries have sought ways to foster economic growth by increasing industrial production that needs higher energy consumption. Generally, economic and population growth are major drivers of increasedCO_2emission. CO_2 emissions contribute 65% of greenhouse emissions [5]. The United Nations, through the Kyoto protocol, has made efforts to reduce and regulate the adverse effect of greenhouse gas emissions on global warming and climatic changes [16].

Natural gas is an abundant and the cheapest fossil fuel in Nigeria. Also, it is cheaper and has lower carbon combustion when compared to other fossil fuels. The increase in natural gas utilization in developing and developed economies accelerate economic growth and development [13].

The relationship between energy consumption and economic growth is complex, in which causality can be unidirectional, bidirectional, or neutral. The growth assumption states that a positive relationship exists between energy consumption and GDP growth. Hence, the causality effect goes from energy utilization to economic growth. The assumption is in line with the conservation assumption in [4] that energy conservation policies will not have negative implications on economic growth. Furthermore, feedback or bidirectional assumption states both energy consumption and economic growth cause each other. The neutral assumption states that there is an absence of a granger effect between energy consumption and economic growth.

In line with this backdrop, the study examines the effects of natural gas utilization, CO_2 emissions on the economic growth of Nigeria using the autoregressive distributive lag (ARDL) and the Granger causality method.

II. LITERATURE REVIEW

In past studies, a great amount of work has been done around the effects and causal relationship of energy components on an economy. Also, the growing attention on climate change has led to recent studies which have observed the impact of CO_2 emissions on an economy.

A similar study [8] observes the long-run and causal relationship between CO_2 emissions, energy consumption, and economic growth in Turkey. The results suggest that neither CO_2 emission nor energy consumption cause economic growth. This led to the conclusion that regulating energy consumption and reducing carbon emissions have no effect on the economic output of Turkey.

The relationship between natural gas consumption and economic growth in ten topnatural gas-consuming countries was examined by [8] using the granger causality technique. The general observation shows a long-run relationship between natural gas and economic growth where natural gas has a positive effect on GDP growth. The study suggested that increasing the use of natural gas consumption to ensure energy security will lead to a reduction in carbon emissions and boost economic output.

The study of [2] uses the aggregate energy consumption model to investigate the relationship betweenCO_2 emission, GDP growth, and energy consumption. The result suggests that the impact of CO_2 emissions is negative on natural gas consumption for the Saudi Arabian economy. Furthermore, it is recommended that if the economy shifts from oil to natural gas, the increase in per capita income would reduce CO_2 emissions.

The Johansen cointegration method and granger causality test were examined by [10] the long-run and causal relationship between greenhouse emissions, energy consumption on the economic growth of Pakistan. The result suggests that an increase in energy consumption encourages economic growth but increases greenhouse gas emissions.

The autoregressive distributive lag (ARDL) model was adopted by [7]to study the relations of energy consumption, environmental emissions, and economic growth in Nigeria. Results show that energy consumption has a positive relationship with economic growth. However, a decrease in CO_2 emission fosters economic growth in the longrun.

In light of the literature review, there are different studies and conclusions from authors in various countries. Hence, we study the effects of natural gas utilization, CO_2 emissions on the economic growth of Nigeria. The importance of the study is to examine the effect of CO_2 emissions on the Nigerian economy with a sustainable approach to support economic growth.

III. MATERIALS AND METHODOLOGY

A. Data

The data used for the study are yearly observations from 1981 to 2015, a total of 35 observations. The variables GDP per capita (GDPC), CO_2 emission, and natural gas utilization data sets are used for the investigation in Nigeria. We retrieve the GDP data series from [14], CO_2 emission from [12], and natural gas utilization (NGU) from [6]. Figure I is the timeseries of the variables of GDP per capita measured in constant LCU, CO_2 emission in tonnes per year, and natural gas utilization (NGU) in billion cubic feet.

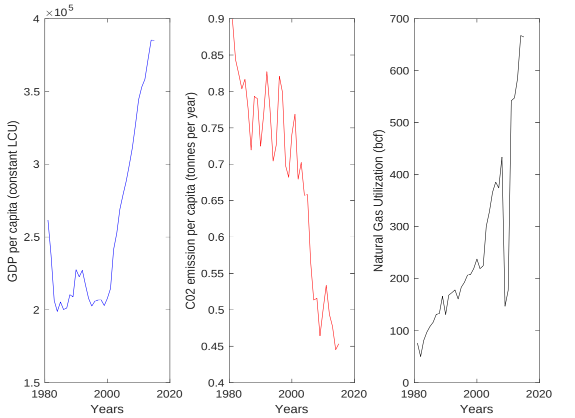

Fig. 1 Timeseries of GDP per Capita, CO_2emission, and Natural gas Utilization

B. Descriptive Statistics

The study describes the statistics of the data series on EVIEWS 10 in Table I, which shows the mean, standard deviation, skewness, kurtosis, and Jarque-Bera. We describe the first and second moments, which indicates that the mean of the distributions is not zero and the standard deviation lies within the 0.2108 and 0.6392. Natural gas utilization (NGU) is considered to be the most volatile series, while CO_2 emission is the least volatile series. The distribution of GDPC and NGU are skewed to the right,while CO_2 emissions are skewed to the left, which shows evidence of asymmetry. The probability density function of the timeseries distributions indicates no extreme changes with the highest kurtosis at 2.53 for NGU. The Jarque-Bera statistics indicate that the timeseries has a normal distribution.

C. Stationarity Analysis

The autoregressive distributive lag model (ARDL) technique requires that the timeseries of the variables are trend stationary. In general, studies observe that most time-series are non-stationary at a level I (0) but become stationary I (1) after being first differenced.

Table 1. Descriptive Statistics of Timeseries

	Variables		
	LOG(GDPC)	LOG(CO_2)	LOG(NGU)
Mean	12.42591	-0.399281	5.350015
Std. Dev.	0.224053	0.210786	0.639157
Skewness	0.749245	-0.704349	0.071143
Kurtosis	2.077529	2.078733	2.531109
Jarque-Bera	4.515621	4.131698	0.350152
Probability	0.104579	0.126711	0.839393

Table 2. Augmented Dickey-Fuller test

	Level			First difference		
Variable(log)	none	constant	constant + trend	none	constant	constant + trend
GDP	2.303323	-0.006586	-1.221067	-3.449587***	-3.415063**	-3.307204*
CO_2	2.210433	0.371139	-1.269336	-5.617432***	-6.437401***	-6.524595***
NGU	1.579946	-1.043565	-2.783454	-1.920496*	-2.482837	-2.407095

***, **, * represent 1%, 5%, and 10% significance level respectively.

Table 3. Bounds Co-Integration Tests

		Significance level	Lower bound	Upper bound
F-statistic	7.135	10%	3.17	4.14
K	2	5%	3.79	4.85
		1%	5.15	6.36

Table 4. Granger Causality Report

Sample: 1981 2015	
Lags: 2	
Null Hypothesis:	F-Statistic
LOG(CO_2) does not Granger Cause LOG(GDPC)	3.96087**
LOG(GDP) does not Granger Cause LOG(CO_2)	4.33958**
LOG(NGU) does not Granger Cause LOG(GDPC)	2.85899*
LOG(GDPC) does not Granger Cause LOG(NGU)	4.65512**
LOG(NGU) does not Granger Cause LOG(CO_2)	4.07641**
LOG(CO_2) does not Granger Cause LOG(NGU)	2.40566

***, **, * represent 1%, 5%, and 10% significance level respectively.

Table 5. ARDL Long-run and Short-run estimates

Dependent Variable: Log(GDPC)		
Parsimonious model: ARDL (1,0,0)		
Panel A: Long-run estimates		
Variable	Coefficient	Standard Error
Log(CO_2)	-1.013078***	0.226767
Log(NGU)	0.145157	0.088415
Panel B: Short-run results		
LOG(GDP(-1))	0.776861***	0.072126
LOG(CO_2)	-0.226057**	0.083511
LOG(NGU)	0.03239*	0.016721
C	2.514756***	0.871402
R-squared	0.973074	
Adjusted R-squared	0.970381	
F-statistic	361.3868***	
Durbin-Watson Stat	1.517178	

***, **, * represent 1%, 5%, and 10% significance level respectively.

The paper examines the stationarity of the variable's timeseries, using the augmented Dickey-Fuller (ADF) unit root test as performed in [1]. Table II shows the stationarity report for the level I (0) and first difference I(1) state. We observe from the report that none of the variables in the level form for the category: none, constant, and constant + trend is non-stationary. However, the variable's timeseries is stationary at a certain significance level after the first difference, which allows for the implementation of the ARDL model.

D. Co-integration analysis

The bounds co-integration technique, as in [11], is a more realistic approach to check for a long-run relationship as it allows for both I(0) and I(1) in the regression model.

The underlying test equation for the bounds co-integration test is the $ARDL\,(p, q_1, q_2)$ model, which is given as:

Level form I (0):

$$\gamma_t = \alpha + \sum_{i=0}^{p} \rho_i y_{t-1} + \sum_{j=0}^{q_1} \gamma_j X_{t-j} + \sum_{j=0}^{q_2} \alpha_j Z_{t-j} + \epsilon_t \qquad (1)$$

First differenced form I (1):

$$\Delta y_t = \alpha + \rho_i y_{t-1} + \gamma_j X_{t-j} + \alpha_j Z_{t-j} + \sum_{i=0}^{p} \rho_i \Delta y_{t-1} + \sum_{j=0}^{q_1} \gamma_j \Delta X_{t-j} + \sum_{j=0}^{q_2} \alpha_j \Delta Z_{t-j} + \epsilon_t \qquad (2)$$

wherey_t is the dependent variable and x_t and z_tAre independent variables.

The decision for the bounds co-integration test are:

$$H_0: \rho = \gamma = \alpha = 0 \Rightarrow No\ Co-integration \Rightarrow No\ long\ run\ relationship$$

$$H_0: \rho = \gamma = \alpha \neq 0 \Rightarrow Co-integration \Rightarrow long\ run\ relationship\ exist$$

The F-statistic is greater than the upper bound regardless of the level of significance. Therefore, we reject the null hypothesis and conclude that long-run relationship among variables gross domestic product (GDP), CO_2 emission, and natural gas utilization (NGU). Hence, we report for the short-run effects and long-run effects.

IV. EMPIRICAL RESULT

A. Granger causality Test

We employ the Granger causality technique as [9], [16] to indicate how occurrences in a variable cause another in Nigeria. The report in table IV shows the rejectionof the null hypothesis where there is an indication of significance at 5% or 10% level. The study observes that GDP PER capita causes CO_2 emission and vice versa. Also,NGU causes GDPC and vice versa, and NGU causes $CO_{2,}$ butCO_2 does not granger cause GDP.

B. ARDL results and interpretation

The study presents results for the long-run and short-run estimates in table V. We explain the results on a threshold of 10% significance level.

Model Interpretation (Long-run):

- There is a negative relationship between GDP and CO_2 emissions. The sign coefficient of CO_2 is negative.
- By implication, a decrease in CO_2 emissions by 1% will lead to a 1.013% increase in GDP since they are directly proportional.
- The long-run effect indicates that NGU is insignificant at the threshold level of 10%.
- The coefficient of CO_2 emissions is statistically significant at a 5% level. This makes the regressor a good predictor of GDP. However, the coefficient of natural gas utilization is insignificant in the model.
- The adjusted R-squared accounts for about 97.3%, which indicates the predictive power of the independent variables on the dependent variable (GDP) is very high since the unexplained component is 2.7%.
- The Durbin-Watson statistic is greater than the R-squared, which eliminates every action of spurious results.
- The overall model is significant judging by the F-statistic, which is significant at the 1% level.

Model Interpretation (Short-run)

- There is a negative relationship between GDP and CO_2 emissions. The sign coefficient of CO_2 is negative. However, there is a positive relationship between GDP and NGU, as indicated by the positive coefficient.
- By implication, a decrease in CO_2 emissions by 1% will lead to a 0.23% increase in GDP. However, an increase in NGU by 1% leads to a 0.03% increase in GDP.
- The coefficient of CO_2 emissions and NGU are statistically significant at 5% and 10% level respectively. This makes the regressors a good predictor of GDP.

C. Post-diagnostic Tests

a) Linearity

$$\mathrm{H_0: linear}$$

$$\mathrm{H_1: Non-linear}$$

$$[t-statistic\ (df=29)] = 0.4843$$

The original model is linear since the computed statistics are not significant at any level.

b) Multicollinearity

$$\log(GDP(-1)): [VIF(Centered)] = 5.1404$$

$$\log(C02): [VIF(Centered)] = 6.4840$$

$$\log(NGU): [VIF(Centered)] = 2.3432$$

The degree of collinearity in the model falls within the allowable threshold. There is no evidence of severe multicollinearity problem since the calculated VIF < 10.

c) Heteroscedasticity

$$\mathrm{H_0: Constant\ Variance}$$

$$\mathrm{H_1: Non-Constant\ variance}$$

$$[F-stat(df{:}1{,}31)] = 0.2249$$

$$[F-stat(df{:}2{,}29)] = 0.6527$$

$$[F-stat(df{:}3,27)] = 0.8938$$

The variance of the error term in the estimated model is constant, judging by the F-statistics, which is not significant. This indicates homoscedasticity.

e) Non- autocorrelation

$$\mathrm{H_0: There\ is\ no\ autocorrelation}$$

$$\mathrm{H\_1: There\ is\ a\ presence\ of\ auto-correlation}$$

$$[F-statistics\ (df{:}1{,}28)] = 0.3948$$

$$[F-statistics\ (df{:}2{,}27)] = 0.5320$$

$$[F-statistics\ (df{:}3{,}26)] = 0.7064$$

There is no presence of serial correlation in the model since the probability value is not significant, so we accept the null hypothesis.

f) Normality

$$H_0: \text{Normal distribution}$$

$$H_1: \text{non} - \text{normal distribution}$$

$$\text{Jarque} - \text{Bera}: 0.1282$$

The residual term is normally distributed judging by the Jarque-Bera statistics, which is not statistically significant. Therefore, we accept the null hypothesis.

The post-diagnostic tests suggest that the ARDL model is appropriate for the study, and the results are consistent with [7] and [10]. Energy consumption has a positive relationship with economic growth, while the decrease in CO_2 emission fosters economic growth in the short-run and longrun.

V. CONCLUSION AND POLICY RECOMMENDATION

One of the major challenges of the Kyoto Protocol to United Nations Framework Convention on Climate Change (UNFCCC) is to optimize the utilization of fossil fuels in a sustainable manner in order not to increase greenhouse emissions. Therefore, the critical decision is with balancing fossil fuel consumption like natural gas and CO_2emission optimally that continuously encourage economic growth.

The paper examines the causality and co-integration relationship between natural gas utilization, CO_2 emissions, and economic growth in Nigeria from 1981 to 2015 using the granger causality technique and autoregressive distributive lag approach.

Granger causality test results show that GDP per capita and CO_2 emissions cause bi-directionally. Also, natural gas utilization and GDP per capita cause each other bi-directionally. However, causality for natural gas utilization and CO_2 emissions is unidirectional,where natural gas causes CO_2 emissions.

The bounds co-integration tests show that natural gas utilization, CO_2 emissions, and GDP per capita have a long-run relationship. The ARDL long-run effect shows that a decrease in CO_2 emissions will foster economic growth. Although, the effects of natural gas utilization, in the long run,are insignificant. The short-run effect shows that a decrease in CO_2 emissions also encourages economic growth. The increase in natural gas utilization supports economic growth. The magnitude of carbon emission as it affects GDP per capita growth is lesser in the short-run with 0.23% when compared to the long-run that is 1.013%. The empirical evidence suggests that in the long-run,CO_2 emissions from natural gas utilities are expected to reduce drastically, which will improve economic growth.

The policy recommendation that could be inferred from the study is that Nigeria should invest more in natural gas with less carbon emission and alternative energy sources like hydro, solar, and wind. This will reduce greenhouse emission effects which will, in turn, lead to the sustainable growth of the economy and environment.

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