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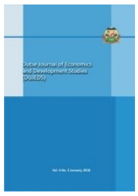

# GRANGER CAUSALITY BETWEEN ECONOMIC GROWTH AND CARBON DIOXIDE EMISSION IN NIGERIA: EVIDENCE FROM TODA-YAMAMOTO

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**Abstract**

*One of the major challenges and of course a threat to human existence is global warming resulting from climatic change. This paper examined the causal relationship between Economic Growth (RGDPP) and carbon dioxide emission ($C0_2$) in Nigeria using time series data from 1970-2017 sourced from World Development Indicator (2018). Stationarity test using Philips-Perron revealed that data series are stationary at first differenced. The cointegration and causal relationship between RGDPP, energy consumption (ENCON) and $C0_2$ is investigated on the basis of Johansen's technique and the VAR Granger Causality/Block Exogeneity Wald Tests proposed by Toda-Yamamoto respectively. The evidence shows that real gross domestic product per capita, energy consumption and carbon dioxide emission are causally related in the long-run. Precisely the evidence established bi-directional causality between real gross domestic product per capita and carbon dioxide emission. There is however, a unidirectional causality from energy consumption to carbon dioxide emission. The same unidirectional causality is established from energy consumption to economic growth. The Impulse Response Functions result revealed that carbon dioxide emission responded positively to own shocks through the time horizon but alternate form positive to negative due to innovations from real gross domestic product per capita. The Variance Decomposition analysis revealed that 2.435% and 9.189% of the variation in $C0_2$ is caused by real gross domestic product per capita and energy consumption respectively while 88.374 is caused by own shocks. The research recommends energy expansion policies like energy subsidy or low energy tariff, would be necessary for economic agents to use their excess resources to acquire low carbon technologies aimed at reducing emissions and at the same time achieve sustainable economic growth. Policies to promote long term investment in clean and renewable energy sources such as solar power, wind power should be applied.*

**Keywords:** $C0_2$, Economic Growth, Energy Consumption, Toda-Yamamoto, Cointegration.
**JEL Classification:** O44, Q41, Q56.

## Introduction

One of the major challenges and of course a threat to human existence is global warming resulting from climatic change. The accumulation of greenhouse gas emissions, most noticeably in the form of carbon dioxide (a chemical compound found in earth's atmosphere as gas) through the activities of man, plays an important role in global warming. Developing as well as developed countries found themselves in a dilemma between sustainable economic growth and environmental quality sustainability. Sustainable economic growth requires energy consumption for the production of goods, hence carbon dioxide emission which affects environmental quality by trapping and remitting radiation. Carbon dioxide emission is widely considered the major cause of Green House Gasses (GHGs) (Edoja, Aye, & Abu, 2016). In order to reduce the emission of GHGs, there have been several international attempts, of which the Kyoto protocol agreement, signed in 1997 is the most notable one. The Kyoto Protocol is a protocol to the United Nations Framework Convention on Climate Change and the key feature of the Kyoto protocol is to reduce the collective emission of GHGs of 39 industrialized countries and the European Union (Kasman & Duman, 2015; Uddin, Salahuddin, Alam & Gow, 2017).

Grossman and Krueger (1995) noted that to achieve a high level of growth a country needs more inputs to enlarge its outputs, leading to an increase in the waste and emissions generated through the production of economic activities. Energy is considered to be the life line of an economy, the most vital instrument of socio-economic development and recognized as one of the most important strategic commodities (Sahir & Qureshi, 2007).

The outbreak of various environmental hazards as a result of the changes in environmental temperature or atmospheric imbalance from carbon dioxide emission in recent years is so alarming in Nigeria. Olusanya and Olumiyiwa, (2012) identified such hazards to include, among others, the vulnerability of the economic sector to the recurrent droughts, flood and cyclones, reduction of some plant and animal populations, spread of diseases vectors including malaria, freezing and breaking-up of ice on rivers and lakes, reduction in food production and agricultural productivity, increase in death rate and threat to sustainable development.

The study is structured as follows: section one is the introduction, section two is literature review. Section three deals with methodology of the study. This is followed by results and discussion in section four. Conclusion and recommendations are handled in section five.

**Literature Review**

The relevance of carbon dioxide as a determinant of economic growth has attracted many researchers such as Soytas and Sari (2009), Tiwari (2011) and Olusanya and Olumiyiwa, (2012), to investigate the relationship between the two variables. An empirical study carried out by Bing, Yong, Katrin and Chengpeng lu (2014) investigate the relationship between $CO_2$ emission, fossil energy consumption and economic growth from the period 1970-2008 in nine European countries based on granger causality test approach. The result revealed that there are various feedback causal relationships between carbon emission, energy consumptions and economic growth with both unidirectional and dual directional Granger Causality. The study of the relationship between carbon dioxide ($CO_2$) emissions and economic growth by Jo Hui and Ya-fang (2013); Chung Yuan and Chung Li (2013) investigate the nexus between carbon dioxide ($CO_2$) emission per capita and economic growth in Next Eleven (N-11) over the period 1981- 2009. The result confirms that there are positive long run relationship among $Co_2$ emissions, electric power consumption, energy use and gross domestic product (GDP). Their study also shows bi-directional causality between $CO_2$ emission and electric power consumption. Tiwari (2011) examine both static and dynamic framework between energy consumption, $CO_2$ emissions and economic growth in India using Granger approach in vector autoregressive (VAR) framework. They found from the VAR analysis that energy consumption, capital and population Granger cause economic growth while impulse response functions (IRF) and variance decomposition (VD) analysis result indicates that $CO_2$ emission has positive impact on energy use and capital but negative impact on population and GDP. Energy consumption has positive impact on $CO_2$ emission and GDP but its impact is negative on capital and population.

Farzana and Muhammed (2016) investigate a causal relationship between energy consumption, energy price and economic growth in Africa using Johansen's Maximum likelihood Cointegration and Error Correction Model. The result for Angola suggests unidirectional Granger Causality running from income to energy consumption. Akinbobola, Adedokun and Nwosa (2015) examine the impact of climate change on the composition of agricultural output in Nigeria, from 1981-2011. Using Ordinary Least Square (OLS) estimation technique, they observe that with exception of fishery production, climate change have a significant and positive impact on the composition of agricultural output in Nigeria.

Zhang and Cheng (2009) found unidirectional Granger causality running from economic growth to energy consumption and energy consumption to pollution emissions in the long run, while Ang (2007) found unidirectional Granger causality running from economic growth to energy consumption and pollution emissions in the long-run. Olusanya and Olumiyiwa (2012) investigate the long run relationship between energy consumption and economic growth in Nigeria with ordinary least square using secondary data from 1985-2010. The result shows that petroleum and electricity are positively related to economic growth in Nigeria, while, coal and gas show a negative relationship with Nigeria economic growth. They conclude that increase energy consumption is a strong determinant of economic growth in Nigeria.

However there is no consensus in these findings; some researchers found a unidirectional causality, others found bidirectional causality, yet others found no causal relationship between the variables. For instance, Soytas, Sari and Ewing (2007) and Soytas and Sari (2009) found unidirectional Granger causality running from energy consumption to pollution emissions in the long run, while Halicioglu (2009) found bidirectional Granger causality in the long run and short run between economic growth and pollution emissions.

Furthermore, most of the works on causal relationship between economic growth and carbon dioxide in Nigeria use ordinary least square method and error correction models in which their respective specification classify variables into endogenous variables and exogenous variables. This study attempts to investigate the causal relationship between economic growth and carbon dioxide emission in Nigeria within VAR frame work. The results of granger causality generated through VAR models are more realistic because right from the specification, all variables are treated as endogenous while in simultaneous, or structural equation models some variables are treated as endogenous and some as exogenous or predetermined (exogenous plus lagged endogenous).

**Methodology**

The data are annual observations on carbon dioxide emission (C02) measured in metric tons per capita as a proxy for economic growth, real gross domestic product per capita (RGDPP) in current US Dollar, and energy consumption measured as kilogram of oil equivalent per capita. The data were obtained between 1970 and 2017 from the World Development Indicators 2018. The natural logarithm of the variables was used.

The researchers adopted Granger Causality/Block Exogeneity Wald Test as proposed by Toda and Yamamoto (1995) for the causality test in order to infer the causal relationship between economic growth (RGDPP) and carbon dioxide emission ($C0_2$). This procedure avoids the problems of testing for Granger causality with respect to the power and size properties of unit root and co-integration tests (Zapata and Rambaldi, 1997). The Toda and Yamamoto (1995) test involves estimation of a vector autoregressive (VAR) model in levels, a method that minimizes the risks associated with incorrect identification of the order of integration of the respective time series and co-integration among the variables. Specifically, the Toda–Yamamoto long-run causality test artificially augments the correct order of the VAR, k, by the maximum order of integration, $d_{max}$, and ensures that the usual test statistics for Granger causality has the standard asymptotic distribution (Wolde-Rufael, 2005). In other words, the Toda-Yamamoto approach fits a VAR model to the levels of the variables, thereby minimizing the risks associated with possible incorrect identification of the order of integration of the series (Mavrotas & Kelly, 2001). The main idea of this method is as Wolde-Rufael (2004) stated ''to artificially augment the correct VAR order, k, by the maximal order of integration, say "$d_{max}$''. Then, a $(k + d_{max})^{th}$ VAR order is calculated and the coefficients of the last lagged $d_{max}$ vector are ignored (Wolde-Rufael 2004, 2005, 2006; Rambaldi and Doran, 1996; Rambaldi, 1997; Zapata and Rambaldi, 1997). Moreso, the Toda-Yamamoto (1995) procedure ensures that the usual test statistic has the convenient asymptotic distribution for which well-founded inferences can be carried out. The functional Toda-Yamamoto model for carbon dioxide emission (C02), real gross domestic product per capita (RGDPP) and energy consumption (ENCOM) is specified below:

$$\ln C0_{2t} = \alpha_0 + \sum_{i=1}^{K} \alpha_{1i} \ln C0_{2t-i} + \sum_{j=k+1}^{K+d_{max}} \alpha_{1j} \ln C0_{2t-j} + \sum_{i=1}^{K} \phi_{2i} \ln RGDPP_{t-1} + \sum_{j=k+1}^{K+d_{max}} \phi_{2j} \ln RGDPP_{t-j}$$

$$+ \sum_{i=1}^{K} \varpi_{3i} \ln ENCON_{t-i} + \sum_{j=k+1}^{K+d_{max}} \varpi_{3j} \ln ENCON_{t-j} + \varepsilon_{1t} \quad . \quad . \quad . \quad (1)$$

$$\ln RGDPP_t = \beta_0 + \sum_{i=1}^{K} \beta_{1i} \ln C0_{2t-i} + \sum_{j=k+1}^{K+d_{max}} \beta_{1j} \ln C0_{2t-j} + \sum_{i=1}^{K} \psi_{2i} \ln RGDPP_{t-1} + \sum_{j=k+1}^{K+d_{max}} \psi_{2j} \ln RGDPP_{t-j}$$

$$+ \sum_{i=1}^{K} \Omega_{3i} \ln ENCON_{t-i} + \sum_{j=k+1}^{K+d_{max}} \Omega_{3j} \ln ENCON_{t-j} + \varepsilon_{2t} \quad . \quad . \quad . \quad (2)$$

$$\ln ENCON_t = \delta_0 + \sum_{i=1}^{K} \delta_{1i} \ln C0_{2t-i} + \sum_{j=k+1}^{K+d_{\max}} \delta_{1j} \ln C0_{2t-j} + \sum_{i=1}^{K} \Phi_{2i} \ln RGDPP_{t-1} + \sum_{j=k+1}^{K+d_{\max}} \Phi_{2j} \ln RGDPP_{t-j}$$

$$+\sum_{i=1}^{K} \xi_{3i} \ln ENCON_{t-i} + \sum_{j=k+1}^{K+d_{\max}} \xi_{3j} \ln ENCON_{t-j} + \varepsilon_{3t} \quad . \quad . \quad . \quad (3)$$

Where:
$C0_2$ = Carbon Dioxide Emission
RGDPP = Real Gross Domestic Product Per Capita
ENCON = Energy Consumption
$\varepsilon$ = Stochastic error term called shocks or impulse or innovations in the VAR

t = Current time

**Results and Discussion**
**Unit Root Test Result**
Stationarity test is conducted using Augmented Dickey- Fuller (ADF) and Philips-Perron (PP) tests and the result is presented in table 1.

**Table 1: Summary of Unit Root Test Result Using Philips-Perron (PP) Test.**

| PHILIPS-PERRON | | | | | | | |
|---|---|---|---|---|---|---|---|
| | LEVELS | | | FIRST DIFFERENCED | | | |
| Variable | t-statistic | Critical value | p-value | t-statistic | Critical value | p-value | *I(d)* |
| Log($C0_2$) | -1.889308 | -2.925169 | 0.3344 | -8.212179 | -2.926622 | 0.0000**a***** | *I(1)* |
| Log(RGDPP) | -0.811583 | -2.925169 | 0.8065 | -6.271988 | -2.926622 | 0.0000**a***** | *I(1)* |
| Log(ENCON) | -2.167886 | -2.926622 | 0.2204 | -6.649697 | -2.928142 | 0.0000 **a***** | *I(1)* |

**Source: Researchers' computation using E-view 9.0**
Note: *** implies statistical significance at 1% levels respectively. Also, '*a*' denotes model with constant.

The results of the unit root test presented in table 1 revealed that all the variables are non-stationary at levels but they are stationary at first difference, hence they are integrated of order one. Therefore unrestricted VAR may not be suitable for the estimation of the model. This calls for cointegration test to determine the appropriate estimating technique. Before the cointegration test it is necessary to determine lag selection order.

**VAR Lag Order Selection Criteria**
The result of VAR lag order selection test (Konya, 2000; Wolde-Rufael, 2004) which shows the optimal lag structure for VAR is presented in the table2:

**Table 2: Lag Order Selection Result**

| Lag | LogL | LR | FPE | AIC | SC | HQ |
|---|---|---|---|---|---|---|
| 0 | 30.00761 | NA | 4.84e-05 | -1.421453 | -1.292170 | -1.375455 |
| 1 | 131.1912 | 181.0653 | 3.79e-07 | -6.273220 | -5.756088 | -6.089228 |
| 2 | 137.5337 | 10.34827 | 4.41e-07 | -6.133351 | -5.228369 | -5.811366 |
| 3 | 142.5992 | 7.464946 | 5.56e-07 | -5.926272 | -4.633441 | -5.466293 |
| 4 | 148.2160 | 7.390505 | 6.98e-07* | -5.748208* | -4.067528* | -5.150235* |
| 5 | 162.4055 | 16.42996* | 5.76e-07 | -6.021340 | -3.952811 | -5.285373 |
| 6 | 176.2996 | 13.89410 | 5.06e-07 | -6.278924 | -3.822545 | -5.404963 |
| 7 | 184.7823 | 7.143395 | 6.32e-07 | -6.251702 | -3.407474 | -5.239748 |
| 8 | 195.1601 | 7.100560 | 7.90e-07 | -6.324215 | -3.092137 | -5.174266 |
| 9 | 214.0397 | 9.936641 | 7.39e-07 | -6.844195 | -3.224268 | -5.556253 |

**Source: Researchers' computation using E-view 9.0**
* indicates lag order selected by the criterion

The result depicts that majority of the lag selection criteria, such as the Final Prediction Error, Akaike Information Criterion, Schwarz Information Criterion and Hannan-Quinn Information Criterion, selected the optimum lag length of 4 at 5% level of significance. It is only Sequential Modified LR test statistic that suggests the optimum lag length of 5. More so, empirical analysis for the purpose of forecasting requires Akaike Information Criterion (AIC) for optimal lag selection. Hence the Lag length of 4 will be used in Johansen Cointegration and estimation of the VAR.

**Co-integration Test**

The result of Johansen Cointegration Test is presented in table 3:

**Table 3: Unrestricted Cointegration Rank Test (Trace)**

| Hypothesized No. of CE(s) | Eigenvalue | Trace Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.449278 | 49.98576 | 35.19275 | 0.0007 |
| At most 1 * | 0.309124 | 24.93173 | 20.26184 | 0.0105 |
| At most 2 * | 0.200539 | 9.400317 | 9.164546 | 0.0451 |

Trace test indicates 3 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values

Unrestricted Cointegration Rank Test (Maximum Eigenvalue)

| Hypothesized No. of CE(s) | Eigenvalue | Max-Eigen Statistic | 0.05 Critical Value | Prob.** |
|---|---|---|---|---|
| None * | 0.449278 | 25.05403 | 22.29962 | 0.0201 |
| At most 1 | 0.309124 | 15.53141 | 15.89210 | 0.0569 |
| At most 2 * | 0.200539 | 9.400317 | 9.164546 | 0.0451 |

Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level
* denotes rejection of the hypothesis at the 0.05 level
**MacKinnon-Haug-Michelis (1999) p-values
*Source: Researchers' Computation Using E-view 9.0*

Table 3 presents the outcome of cointegration test conducted using both the trace test and max-eigenvalue test. The trace statistic indicate three cointegrating equations, while max-eigenvalue statistic indicate one cointegrating equation, hence the presence of a long-run relationship among carbon dioxide emission, economic growth and energy consumption at 5% level of significance. That is, the test statistic for each is greater than the critical value and it is reflected by the corresponding probability value.

**Post Estimation Test of VAR Estimates**

In order to ensure that the model is correctly specified and also to avoid spurious results, examination of model misspecification as suggested by Enders, (1995) and Wolde-Rufael, (2005) was carried out using the following tests:

**Serial Correlation Test Result**

| Lags | LM-Stat | Prob |
|---|---|---|
| 1 | 13.23037 | 0.1525 |
| 2 | 10.76592 | 0.2921 |
| 3 | 11.88100 | 0.2201 |
| 4 | 19.14501 | 0.1240 |

**Source: Researchers' Computation Using E-view 9.0**

Serial correlation occurs when observations have a natural sequential order. Table 4 shows that the LM-Statistics at lag 1- 4 ( with the values 13.23037, 10.76592, 11.88100 and 19.14501 respectively) with p-values of 0.1525, 0.2921, 0.2201 and 0.1240 respectively indicates the absence of serial correlation in the model since the p-values are greater than 5% level of significance. Thus, we may conclude that there is no presence of serial correlation in the model.

**Heteroscedasticity**

**Table 5: VAR Residual Heteroscedasticity Test Result: Include no cross term**

Joint test:

| Chi-sq | Df | Prob. |
|---|---|---|
| 148.4168 | 144 | 0.3833 |

Individual components:

| Dependent | R-squared | F(24,18) | Prob. | Chi-sq(24) |
|---|---|---|---|---|
| res1*res1 | 0.376431 | 0.452753 | 0.9646 | 16.18652 |
| res2*res2 | 0.375029 | 0.450055 | 0.9657 | 16.12623 |
| res3*res3 | 0.540955 | 0.883827 | 0.6174 | 23.26107 |
| res2*res1 | 0.712695 | 1.860462 | 0.0902 | 30.64587 |
| res3*res1 | 0.757618 | 2.344284 | 0.1340 | 32.57756 |
| res3*res2 | 0.529114 | 0.842742 | 0.6576 | 22.75190 |

**Source: Researchers' Computation using E-view, 9.0**

Heteroscedascity occurs whenever the variance of the unobserved error term, changes across different segments of the population over time. Table 5 indicates that the VAR Residual Heteroscedasticity test with a chi-square value of 148.4168 and a p-value of 0.3833 confirms the absence of Heteroscedasticity in the model since its p-values are greater than 5% level of significance and this ensures the reliability of the VAR model. Both the joint test and the individual components indicate no element of heteroscedasticity of the series.

**Parameter Stability Test**

To ensure the reliability of the coefficient of the Normalized Cointegration model, the study adopted the AR Root Stability Test. The estimated VAR will be assumed to be stable if all roots fall within the circle. The result is presented in figure1.

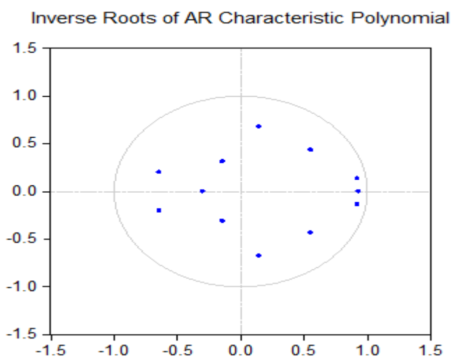


**Fig. 1: Stability Test**

*Source: Researchers' Computation Using Eview 9.0*

From figure 1, the outcome implies that the VAR model is stable, since the polynomial roots fall within the unit circle.

## Granger Causality Test

**Table 7: VAR Granger Causality/Block Exogeneity Wald Tests**

Dependent variable: LOG(C02)

| Excluded | Chi-sq | df | Prob. |
|---|---|---|---|
| LOG(RGDPP) | 3.089762 | 4 | 0.0429 |
| LOG(ENCON) | 4.209212 | 4 | 0.0084 |
| All | 5.752784 | 8 | 0.0049 |

Dependent variable: LOG(RGDPP)

| Excluded | Chi-sq | Df | Prob. |
|---|---|---|---|
| LOG(C02) | 7.064448 | 4 | 0.0325 |
| LOG(ENCON) | 15.04706 | 4 | 0.0046 |
| All | 19.96203 | 8 | 0.0105 |

Dependent variable: LOG(ENCON)

| Excluded | Chi-sq | Df | Prob. |
|---|---|---|---|
| LOG(C02) | 3.562999 | 4 | 0.4684 |
| LOG(RGDPP) | 5.595110 | 4 | 0.2315 |
| All | 12.84786 | 8 | 0.1172 |

*Source: Researchers' Computation Using E-view 9.*

The result of Granger causality test as presented in table 7 revealed that there exist a bidirectional causality between Economic Growth (RGDPP) and carbon dioxide emission ($C0_2$) in Nigeria, hence the null hypothesis that RGDPP does not granger causes $C0_2$ is rejected at 5% level of significance. In like manner, the null hypothesis that $C0_2$ does not granger causes RGDPP is also rejected at 5% level of significance. This implies that, externality of energy use will set back economic growth. Although $C0_2$ is ordinarily hypothesized to be a function of real per capita GDP, there are some reasons which this could be a bidirectional relationship, as it can be reasoned that $C0_2$ is an input to the macroeconomic production function. However, there is a unidirectional causality from energy consumption to carbon dioxide emission. There is also a unidirectional causality running from energy consumption to economic growth. This is in consonance with the findings of Olusanya and Olumiyiwa (2012). This shows that energy consumption can increase economic growth but economic growth may not necessarily increase energy consumption. This result spells out the crude nature of our production techniques whereby, traditional methods of production are still used and less of modern technology in Nigeria. This implies that some aspect of growth is generated not necessarily from energy consumption. This depicts the traditional nature of the production process in Nigeria.

**Impulse Response Functions (IRFs) Test**

The impulse response functions are dynamic simulations showing the response of an endogenous variable over time to a given shock. The impulse response functions result as presented in figure 2 shows the impulse response function result of carbon dioxide emission ($C0_2$), real gross domestic product per capita (RGDPP) and energy consumption (ENCON) over a 10-year period. IRFs show the variation in a variable that is explained by innovations (impulses) in it and by the other variables in the system. For example it explains what proportions of the changes in a particular variable that can be attributed to its own shock as well as the shocks introduced by other explanatory variables.

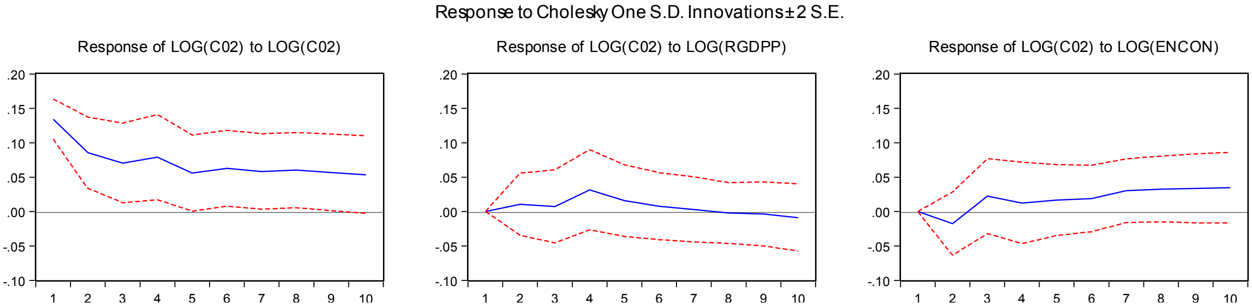


**Fig. 2 Response to Cholesky one S.D innovations**

*Source: Researchers' Computation Using E-view 9.0*

It is evident from figure 2 that one SD shock/innovation in $CO_2$ emissions has positive impact on its own value throughout the horizon/periods. A one SD shock/innovation in RGDPP has positive impact on carbon dioxide emission in the first 7 horizon/periods but became negative in the 8$^{th}$ horizon/periods up to the remaining horizon/periods. Energy consumption increases GDP and $CO_2$ emissions. The finding is in agreement with those of Tiwari (2011). However, one SD shock/innovation in energy consumption has negative impact on carbon dioxide in the first 2 years but became positive in two and half horizon/periods up to the 10$^{th}$ horizon/periods.

**Variance Decomposition Test**

The Variance Decomposition as a forecast error decomposition process attempts to determine how much of the forecasted error variance of each of the variables can be explained by the exogenous shocks of other variables in the VAR system, from the short and long run periods (Asongo, 2018). The result for the variance decomposition for carbon dioxide emission is presented in table 8.

**Table 8: Variance Decomposition of LOG(C02):**

| Period | S.E. | LOG(C02) | LOG(RGDPP) | LOG(ENCON) |
|---|---|---|---|---|
| 1 | 0.134273 | 100.0000 | 0.000000 | 0.000000 |
| 2 | 0.160454 | 98.39710 | 0.422391 | 1.180513 |
| 3 | 0.176872 | 96.88454 | 0.520266 | 2.595196 |
| 4 | 0.196646 | 94.52222 | 2.981521 | 2.496256 |
| 5 | 0.205705 | 93.74150 | 3.311296 | 2.947202 |
| 6 | 0.216043 | 93.43551 | 3.124640 | 3.439849 |
| 7 | 0.225796 | 92.17691 | 2.876852 | 4.946235 |
| 8 | 0.235926 | 90.92556 | 2.643798 | 6.430646 |
| 9 | 0.244973 | 89.68584 | 2.473337 | 7.840821 |
| 10 | 0.253279 | 88.37411 | 2.435935 | 9.189951 |

*Source: Researchers' Computation Using E-view 9.0*

The result presented in table 8 revealed that $C0_2$ was largely driven by itself significantly ranging from 100% to 88.37%. Also ENCON, which appeared as the second driver of carbon dioxide emission contributed about 2.496% to variations in $C0_2$ in the 4$^{th}$ period and thereafter increased to 6.430% in the 8$^{th}$ period and 9.189% in the 10th period. While variance in $C0_2$ caused by economic growth (RGDPP) stand at 2.981%, 2.643% and 2.435% in the 4$^{th}$, 8$^{th}$ and 10$^{th}$ periods respectively. This result implies that the predominant source of variation in $C0_2$ is energy consumption. Economic growth accounts for marginal variation in $C0_2$. This implies that most of the energy consumed is not for economic activities, e.g. Gas flaring and the use of local energy sources for cooking as well as the use of old private cars.

**Conclusion and Recommendations**

This study examined the relationship between economic growth and carbon dioxide in Nigeria using time series data from 1970 to 2017. Stationarity test, using Philips-Perron test revealed that all the variables (C02, RGDPP and ENCON) have unit root problem. However, the variables became stationary at first difference. Johansen cointegration test established a long run relationship between carbon dioxide emission, economic growth and energy consumption.

The VAR Granger Causality/Block Erogeneity Wald Tests was applied to test causality between the three variables and the result indicated a bi-directional causal relationship between carbon dioxide emission and economic growth. This implies that reduction in carbon dioxide will retard economic growth. Growth that is generated through the use of modern technology that reduces carbon dioxide emission is the best option in this situation. This result gives credence to the fact that the expansion in carbon dioxide emission implies industrialization and hence economic growth process in Nigeria. The result also revealed a unidirectional causality between energy consumption and carbon dioxide emission running from energy consumption to carbon dioxide emission as well as energy consumption to economic growth.

The Impulse Response Functions Test clearly shows that $C0_2$ responded positively to own shocks. Shocks from RGDPP exerted positive on $C0_2$ for the first $7^{th}$ time period and thereafter became negative. However, shocks from ENCON exerted negatively on C02 in the first two years and turned positive, after two and half years, throughout the time horizon. This also clearly shows that the RGDPP and ENCON has impacted positively on carbon dioxide emission in Nigeria. On the other hand the Variance Decomposition Analysis revealed that 2.435% and 9.189% of the variation in $C0_2$ was caused by RGDPP and ENCON respectively while 88.374 is caused by own shocks.

Given the empirical results, it is recommended that energy expansion policies like energy subsidy or low energy tariff for instance, would be necessary for economic agents to use their excess resources to acquire low carbon technologies aimed at reducing emissions and at the same time achieve sustainable economic growth since these not only keep the economy green but also preserve the environment for future generations. It calls for policies to promote long term investment in clean and renewable energy sources such as solar power, wind power and natural gas and less emphasis on non-renewable energy such as coal, petroleum and their derivatives that deplete very fast and hence are detrimental to the environment. Emission standards should be set for industries and emission monitoring strategies should be put in place to ensure compliance.

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