GROWTH, FOSSIL FUEL ENERGY CONSUMPTION AND CARBON EMISSIONS IN NIGERIA

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Abstract

The causal relationships among economic growth, energy consumption and carbon emissions have attracted much interest in economic literature. The views on the direction of this relationship are divergent and empirical evidences vary, depending on the sources and pattern of energy consumption of the economy examined. Although evidence exists, pointing to the fact that fossil fuel energy has been the major energy source in Nigeria. But the benefit of this energy to economic growth and the environmental hazard associated with the use of this type of energy has not received enough empirical studies in Nigeria. This study therefore examined the causal relationships among economic growth, fossil fuel energy consumption and carbon emissions in Nigeria for the period of 1970 to 2013. The study employed Johansen Cointegration approach to examine the existence of possible long-run relationship among variables and the VAR Granger Causality Test. Estimated results of the study established cointegration among fossil fuel energy consumption, carbon emissions and economic growth, which implies that a long-run relationship exist among the variables. The study however found that this long-run relationship does not translate to causal relationships. On this basis, the study recommended that adequate attention should be given to environmental impacts of fossil fuel energy consumption and that Nigeria should substitute fossil fuel with alternative energy that has less carbon emissions, as the implication of such policy will not affect economic growth in Nigeria.

Keywords: fossil fuel energy, carbon emissions, economic growth, environmental hazard, cointegration, causality

INTRODUCTION

In human history energy has played an important role. Even in the period of agricultural revolution, energy has been one of the key drivers of the industrial revolution. The role becomes more evident in modern economies because of their increasing dependence on energy to ensure sustainable economic development and growth by raising productivity and facilitating income generation and employment (Sambo, 2011; Tajudeen, 2012). Energy is essential to our way of life. However, a large portion of the world's energy need is met through fossil fuel, the reserve of which is rapidly running out (Chukwu, Isa, Ojosu, & Olayande, 2015). From the beginning of the Industrial Revolution, fossil fuel has been the major source of energy supply, and we are still in the age of fossil fuel energy (Ishida, 2012).

Nigeria is one of the leading producers and users of fossil fuel in the world (Aremu, 2014). Fossil fuel energy is attractive in Nigeria not only because it is available but also because we have learned to use it so effectively. Nigeria is well endowed with a variety of fossil energy type, such as crude oil, natural gas and coal. Coal as an energy source is considered to be the oldest commercial fossil fuel used in Nigeria. However, since the discovery of oil in commercial quantities in Nigeria, coal was given less relevance and became highly neglected (Odularu & Okonkwo, 2009). Although, natural gas occur in associated form with crude oil, Nigerian gas reserves are three times greater than its oil reserves (Onakoya, Onakoya, Jimi – Salami & Odedairo, 2013).

Fossil fuel energy is vital in economic growth both directly as an input in the production process and indirectly, as a complement to labour and capital inputs in Nigeria. Fossil fuel constitutes the major source of energy for Nigeria and the sole source of energy for the transport sector (Ogundari, Momodu, Famurewa, Akarakiri & Siyanbola, 2011). It provides energy services that power the industrial, transport, household and other sectors of the Nigerian economy. Statistical record from Energy Commission of Nigeria, (2010) reveals that industrial sector consumed about 748200 tone of fossil fuel in 2009. Fossil fuel produces readily available and instantaneous supply of electricity in Nigeria. Many electric power plants burn fossil fuel (natural gas) to generate electricity for energy needs. Fossil fuel is therefore the oil that lubricates the engine of growth in Nigeria. According to Central Bank of Nigeria Annual Report and Statement of Account for various years, the share of coal, hydro power, natural gas and petroleum products in the total energy consumption in 1975 were 2.6 per cent, 19.0 per cent, 8.8 per cent and 69.6 per cent respectively. By 2011, Nigerian energy consumption mix continued to be dominated by petroleum products (72.1 per cent), followed by hydro power (18.7 per cent), natural gas (9.0 per cent) and coal (0.18 per cent).

This is an evident to the fact that fossil energy has been the major source of energy consumption in Nigeria since 1970s till date, though not without some costs. Fossil fuel consumption has contributed significantly in altering the environment in Nigeria. These environmental alterations have not always been good (Ogundari et al. 2011). Acid rain and global warming are two of the most serious environmental issues related to large-scale fossil fuel combustion. The effects of these have been devastating, affecting both the environment and human beings inhabiting the environment. The outbreak of various environmental hazards in recent years is alarming. Such hazards include, among others, the vulnerability of the economic sector to the recurrent droughts, flood, decline of some plant and animal populations, spread of malaria, reduction in food production, increase in death rate and threat to sustainable development (Ejuvbekpokpo, 2014). This scenario is largely due to weak institutions, as no feasible abatement measures have been implemented despite the increasing environmental degradation (Alege & Ogundipe, 2013).

The linkage and feedback among fossil fuel energy consumption and growth make it imperative to investigate their causality in Nigeria. It is always believed that hardly can an economy exist, let alone grow without considerably tangible level of energy consumption (Olanrewaju, 2014). In fact, the level of fossil fuel energy consumption in an economy may be an indication that the economy is growing. Conversely, ever-increasing output may generate an ever-increasing stock of pollution that will bring growth to a halt (Romer, 2006). The environment on the other hand, is a source of resources for the economy and a sink for wastes. A clean environment boosts productivity while deterioration in physical conditions of the environment hampers growth (Akinsola & Adeoye, 2014). Thus, empirically unravelling the long-run causality relationship among fossil fuel energy consumption, carbon emissions and economic growth will be very informative. This is because a better understanding of such causality relationship is germane to designing appropriate energy consumption policy and developing sustainable green economy for the country.

BRIEF REVIEW OF RELATED LITERATURE

The relationship between energy consumption and economic growth, as well as economic growth and carbon emissions, has been the subject of intense empirical research during the last decades. Until recently, there have been two parallel literatures on the relationship between economic growth, energy and carbon emissions. The first strand of studies focused on environmental pollutants and economic growth nexus, which are closely related to testing the validity of Environmental Kuznets Curve (EKC) hypothesis. The second strand is related to energy consumption and economic growth linkage. A marriage of these two literatures in which the relationship between energy consumption, economic growth and carbon emissions is examined under a multivariate framework has formed a relatively new area of research.

The study of Kaplan, Ozturk, and Kalyoncu (2011) examined the casual relationship between energy consumption and economic growth in Turkey in 1971-2006 by using two multivariate models and Granger causality tests. According to the results of the study, an increase in energy consumption directly affects economic growth and vice versa. Jaunky (2011) on the other hand examined the relationship among, carbon dioxide emission and income. The study used panel data with data from 1980-2005 on 36 countries with high income levels. The study concluded that there is unidirectional causation in both long and short term from per capita real GDP to CO_2 emission. Consequently, a 1% increase in GDP causes a 0.68% rise in CO_2 in the short term and 0.22% in the long term.

Hossain (2012) examined the dynamic causal relationship between carbon dioxide emissions, energy consumption, economic growth, foreign trade and urbanization in Japan. The study used time series data for the period of 1960-2009. It was found that over time, higher energy consumption in Japan gave rise to more carbon dioxide emissions. As a result, the environment will be polluted more. But in respect of economic growth, trade openness and urbanization the environmental quality was found to be normal good in the long-run. While in China, He, Gao and Wang (2012) examined the direction and existence of the Granger causation relationship between energy consumption, economic growth and direct foreign investments. The study found that there is an unidirectional causation from GDP to energy use and direct foreign investments and also an unidirectional causation from energy consumption to direct foreign investments.

Ishida (2012) investigated the relationship between fossil fuel consumption and economic growth in the world based on a bivariate model. Using the Johansen cointegration technique, its empirical results indicated a relationship between the variables. The results of Granger causality tests based on a vector error-correction model revealed unidirectional long-run causality running from fossil fuel consumption to GDP. The study also investigated the nexus between non fossil energy consumption and GDP, and showed that there is no obvious causality between the variables. But the results of the study were in contrast to the results of a similar study of Ishida (2013) that investigated the relationship between fossil fuel consumption and economic growth in Japan. Using a vector error-correction model, the study revealed bidirectional causality between fossil fuels and GDP and also showed that there is no causal relationship between non-fossil energy and GDP. The results of cointegration analysis, Granger causality tests, and variance decomposition analysis implied that non-fossil energy may not necessarily be able to play the role of fossil fuels.

Ozturk and Acaravci (2013) examined the causal relationship between financial development, trade, economic growth, energy consumption and carbon emissions in Turkey in 1960-2007. According to the results of the study, an increase in foreign trade to GDP ratio results in an increase in per capita carbon emissions and financial development variable has no significant effect on per capita carbon emissions in the long-run. These results also support the validity of EKC hypothesis in Turkey. Still on Turkey, Shahbaz, Khan, and Tahir (2013) examined the relationship among carbon emissions, energy intensity, economic growth and globalization in Turkey for the period of 1970-2010. According to the study, economic growth can be boosted at the cost of the environment.

Similarly, Ozturk, Kaplan and Kalyoncu (2013) examined the short-run and long-run relationship and causality between energy consumption and economic growth in Turkey in 1960-2006 by using Johansen and Juselius cointegration method and vector error correction models. According to the results of the study, there was no short-run causality in both energy consumption and GDP models. The results also confirmed that there was unidirectional long-run causality among variables of interests and the direction of long-run causality was running from per capita GDP to per capita energy consumption. In addition, Bozkurt and Akan (2014) examined economic growth, CO_2 emissions and energy consumption relationship between the periods of 1960 to 2010 in Turkey by using cointegration test. The obtained empirical results from the study indicated that CO_2 emissions have negative effect on economic growth while energy consumption has positive effect on it.

In the case of Nigeria, Omisakin (2009) investigated the dynamic causal and long run relationship among energy consumption, carbon emissions and economic growth in Nigeria within the framework of the Environmental Kuznets Curve (EKC). The study used the bound testing approach to cointegration and found unidirectional causal relationships running from energy consumption to economic growth, energy consumption to carbon emissions and economic growth to carbon emissions. On the other hand, Essien (2010) investigated the effects of the short run and long run causal link between energy consumption, economic growth and carbon emissions in Nigeria over the period 1980-2009. The study applied the techniques of VECM version of Granger causality test. The findings of the study indicated that a neutral hypothesis holds in the short run and a bi-causal relationship holds in the long run between economic growth and energy consumption.

Bello and Abimbola, (2010) investigated whether the level of economic growth influence environmental quality in Nigeria within EKC framework for the periods 1980-2008. The study used the ordinary least squares method and observed that carbon emission in Nigeria is not driven by economic growth but by financial development. The study also showed that the inverted U Environmental Kuznets Curve does not exist in Nigeria. In a similar but slightly distinct study, Chuku and Ndifreke (2012) examined the relationship among energy consumption, trade, the environment and Growth in Nigeria. The study used combined simultaneous approach. The result from the income equation and trade equation suggested that production activities in Nigeria are pollution-intensive and environmentally unfriendly. However, contrary to theoretical expectations, the emissions equation returned a U-shaped Environmental Kuznets Curve for Nigeria. The turning point of the U-shaped EKC relation for Nigeria was estimated at US $423.69 which lies comfortably within the sample range.

Similarly, Akinsola and Adeoye (2014) investigated the relationship among air pollution, economic growth and the Environmental Kuznets Curve (EKC) hypothesis in Nigeria. The study used annual data from 1980-2010 and applied error correction model and the Granger causality test. The result of the study indicated that EKC does not hold for Nigeria, even though economic growth has significant impact on air pollution. The empirical results of Akinsola and Adeoye (2014) and Bello and Abimbola (2010) are in line with the results of Akpan and Chuku (2012) and Alege and Ogundipe (2013) but in sharp contrast with those of Chuku and Ndifreke (2012).

On the other hand, Saibu and Jaiyeola (2013) analyses causal effect of oil production and carbon emission from gas flaring on the growth rate in Nigeria between 1970 and 2011. The result revealed that economic growth rate, change in crude oil production growth rate, crude oil production growth rate, crude oil consumption growth rate, consumption growth rate, change in growth rate of carbon monoxide emission from gas flaring, growth rate of carbon monoxide emission from gas flaring, change in investment growth rate and investment growth rate are significant factors influencing economic growth in Nigeria.

Nnaji, Chukwu and Uzoma (2013) analysed the dynamic causal relationship among carbon emissions, energy consumption, foreign trade and economic growth in Nigeria for the period 1970-2009 in a multivariate framework. The study employed an augmented form of Granger causality and the bounds testing approach to cointegration to test the interrelationship between the variables. The bonds test result indicated that economic growth is determined by energy consumption, carbon emissions, capital and foreign trade. The study also found a unidirectional causality running from energy consumption to economic growth; from energy consumption to carbon emissions; from carbon emissions to economic growth; from capital formation to economic growth and from trade to economic growth. The empirical results of the study revealed that expansion in international trade increases CO_2 emissions, which implies that foreign trade is harmful to environmental quality in Nigeria. This finding is in line with that of Chuku and Ndifreke (2012).

In a similar study, Aguegboh and Madueme (2014) examined the causal relationship between energy consumption and economic growth in Nigeria. The study is particularly noteworthy as it included capital and labour as control variables and employed systematic econometric methods which include Johansen cointegration test and vector autoregressive models (VAR) for Granger causality test. The study used annual data from 1980-2010 and found a unidirectional causality running from oil consumption to GDP. The study also found that gas consumption Granger causes GDP without feedback. The results of the study however contradicted the neoclassical perspective that energy is not a limiting factor to economic growth in Nigeria.

In what seems to be a departure from other studies, Nnaji, Chukwu and Nnaji (2013) investigated the causal relationship among electricity supply, fossil fuel consumption, CO_2 emissions and economic growth in Nigeria for the period 1971-2009, in a multivariate framework. Using the bound test approach to cointegration, the study found a short-run as well as a long-run relationship among the variables. The findings also indicated that economic growth is associated with increased CO_2 emissions while a positive relationship exists between electricity supply and CO2 emissions revealing the poor nature of electricity supply in Nigeria. The study further revealed that electricity supply has no significant impact on economic growth in Nigeria and that policies aimed at reducing carbon emissions in Nigeria will not impede economic growth.

Similarly, Akpan and Akpan (2013) examined the long-run and causal relationship among electricity, carbon emissions and Economic Growth in Nigeria. This study applied a Multivariate Vector Error Correction and used annual time series data from 1970 to 2008. The study found that in the long-run, economic growth is associated with increased carbon emissions, while electricity crisis adversely affects carbon emissions. No support was obtained for the hypothesized Environmental Kuznets Curve (EKC).

It is apparently clear from the above review that most of the studies on energy-environment-growth linkage focused on the total energy consumption with a few focusing on electricity consumption but with mixed results. This is particularly true for Nigeria (see for instance, Essien (2010); Sambo (2011**;** Akpan and Akpan (2013); Sulaiman (2014)). Meanwhile apart from electricity, fossil energy is an important component in the country's energy consumption. The study of Nnaji, Chukwu and Nnaji (2013) appears to be the only notable study on fossil energy for Nigeria. Thus, this paper focused on the causality among economic growth, fossil fuel energy consumption and carbon emissions in Nigeria.

METHODOLOGY

So far, most studies on the relationship between economic growth, energy consumption and carbon emissions have used multivariate models. However, studies using multivariate model faces difficulty when choosing variables to include in the model, as no consensus concerning the theoretical framework upon which to base decisions about which variables to be included. To investigate the causality relationship between economic growth and fossil fuel energy consumption in Nigeria, the study adopted the VAR Granger Causality/Block Exogeneity Wald Tests approach as proposed by Toda and Yamamoto (1995). This followed the econometric models employed by Hossain (2012) and Li and Lin (2015) for Japan. The time series variables used in this study are specified in the following format: CO_2 emissions - metric tons per capita (CO_2), fossil fuel energy consumption - % of total (FFC), real GDP per capita growth - annual % (GDP), urbanization proxy by urban population growth - annual % (URB), industrialization proxy by the % share of industrial sector to GDP (IND) and trade openness (TRD). The data were sourced from Central Bank of Nigeria (CBN) Statistical Bulletins and World Bank Development Indicators (WDI). The percentage share of industrial sector to GDP and trade openness were sourced from CBN (2014), while carbon emissions per capita, fossil fuel energy, real per capita growth and urbanization were sourced from WDI (2014).

The relation is specified below:

$$CO_{2t} = f\left(GDP_t, FFC_t, URB_t, TRD_t, IND_t\right) \quad (1)$$

Econometrically, the model is specified as follows:

$$CO_{2t} = \alpha_0 + \alpha_1 GDP_t + \alpha_2 FFC_t + \alpha_3 URB_t + \alpha_4 TRD_t + \alpha_5 IND_t + \varepsilon_t \quad (2)$$

The estimation began with pre-tests analysis of the variables. The tests include summary statistic, correlation matrix and the unit root test. The unit root test was conducted on each variable using the Augmented Dickey-Fuller test and complemented it with Philip-Perron test. Also, the Johansen Co-integration test was carried out to verify the existence of cointegration among the variables. The co-integration term is known as the error correction term since the deviation from long-run equilibrium is corrected gradually through a series of partial short-run adjustments. This methodology has advantage over others such as the Engle-Granger two-step procedure, because it prevents substantial bias that takes place in OLS estimates of co-integration relations and corrects for autocorrelation and endogeneity parametrically (Johansen, 1995). The VAR Causality model of Toda and Yamamoto (1995) specification for this study is presented as follows:

$$\begin{bmatrix} CO_{2t} \\ GDP_t \\ FFC_t \\ URB_t \\ TRD_t \\ IND_t \end{bmatrix} = A_0 + A_1 \begin{bmatrix} CO_{2t-1} \\ GDP_{t-1} \\ FFC_{t-1} \\ URB_{t-1} \\ TRD_{t-1} \\ IND_{t-1} \end{bmatrix} + A_2 \begin{bmatrix} CO_{2t-2} \\ GDP_{t-2} \\ FFC_{t-2} \\ URB_{t-2} \\ TRD_{t-2} \\ IND_{t-2} \end{bmatrix} + A_3 \begin{bmatrix} CO_{2t-3} \\ GDP_{t-3} \\ FFC_{t-3} \\ URB_{t-3} \\ TRD_{t-3} \\ IND_{t-3} \end{bmatrix} + A_4 \begin{bmatrix} CO_{2t-4} \\ GDP_{t-4} \\ FFC_{t-4} \\ URB_{t-4} \\ TRD_{t-4} \\ IND_{t-4} \end{bmatrix} + A_5 \begin{bmatrix} CO_{2t-5} \\ GDP_{t-5} \\ FFC_{t-5} \\ URB_{t-5} \\ TRD_{t-5} \\ IND_{t-5} \end{bmatrix} + \begin{bmatrix} \varepsilon CO_{2t} \\ \varepsilon GDP_t \\ \varepsilon FFC_t \\ \varepsilon URB_t \\ \varepsilon TRD_t \\ \varepsilon IND_t \end{bmatrix} \quad (3)$$

The Toda and Yamamoto (TY) procedure uses a modified Wald test for putting restrictions on the parameters of the VAR (*k*) from an augmenting VAR ($k + d^{max}$) model, where k is the lag length and d^{max} is the maximum order of integration of variables. The approach which is based on augemented VAR modelling has a Wald test statistic. This modified Wald test has asymptotic chi square (χ^2) distribution regardless of the order of integration of the series or their cointegrating properties and it fits a standard vector autoregression model on levels of the variables. This provides information about the long causality of the series which is ignored in other method that use first differencing.

RESULTS AND INTERPRETATION

In order to ensure that the time series data used for this analysis are in good structure, the estimation begins with the descriptive analysis, correlation analysis, stationarity test and the co-integration analyses of the time series data. These processes enables us to carry out some predetermine operations, where applicable, on the variables, so as to minimize estimation errors and to achieve the unbiased estimator of the models analyses.

The descriptive statistic shows that some of variables are not normally distributed, having large values of standard deviation, Jarque-Bera statistics and near zero probabilities. The mean value of the CO_2 emissions (CO_2) is 0.642, with a standard deviation and Jarque-Bera values of 0.1866 and 1.851 respectively, having probability value of 0.396. While the fossil fuel consumption (FFC) with mean value of 16.431 has standard deviation value of 4.261 and Jarque-Bera statistic and probability values of 16.641 and 0.0002 respectively (see table 1). Evidence that shows that some predomination operation is required to normalized the time series data.

TABLE 1: Descriptive Statistic

	CO_2	FFC	GDP	IND	TRD	URB
Mean	0.642343	16.43158	1.846953	34.49466	5.72E-06	4.500636
Median	0.666346	17.69657	2.556444	36.10121	9.83E-07	4.514953
Maximum	1.007021	21.55328	30.34408	52.99716	2.71E-05	5.314553
Minimum	0.322040	5.123440	-15.45826	4.598569	7.39E-09	3.901429
Std. Dev.	0.186680	4.261598	7.932880	11.50491	7.61E-06	0.396819
Skewness	-0.055145	-1.410375	0.915662	-0.749831	1.165989	0.389038
Kurtosis	2.001029	4.058453	6.288795	3.000871	3.192667	2.105073
Jarque-Bera	1.851864	16.64108	25.97819	4.123146	10.03795	2.578209
Probability	0.396162	0.000243	0.000002	0.127254	0.006611	0.275517
Sum	28.26310	722.9897	81.26595	1517.765	0.000252	198.0280
Sum Sq. Dev.	1.498528	780.9324	2706.015	5691.608	2.49E-09	6.771003
Observations	44	44	44	44	44	44

Source: Eviews estimate

The economic growth variable, proxy by the annual growth rate of Gross domestic product (GDP) has the highest value of Jarque-Bera statistic of 25.978, with 1.846 and 7.932 mean and standard deviation values respectively. Thus, the structure of the data series calls for normalization of the variables; hence, more tests were conducted on each of the variables.

First, the correlation test is carried to ascertain the correlations among the variables under study, before going further to ascertaining their unit root and cointegration status.

TABLE 2: Correlation Matrix

	CO_2	FFC	GDP	IND	TRD	URB
CO2	1	-0.0219	-0.1480	-0.4070	-0.3476	0.5470
FFC	-0.0219	1	-0.2804	0.7535	0.2418	-0.3634
GDP	-0.1480	-0.2804	1	-0.1200	0.2521	-0.2784
IND	-0.4070	0.7535	-0.1200	1	0.4884	-0.6274
TRD	-0.34760	0.2418	0.2521	0.4884	1	-0.7895
URB	0.5470	-0.3634	-0.2784	-0.6274	-0.7895	1

Source: Eviews estimate

The correlation values of the variables under investigation, as presented in table 2, showed an evidence of no multicollinearity among the selected variables. This is because all the values are not in excess of 0.8 in absolute terms, in accordance with econometrics rule of thumb for multicollinearity estimation problem; an indication that the model is correctly specified. Having confirmed the correlation status of the variables, we move further to present the unit root and cointegration tests analyses.

Also the paper examined the unit root structures of the data using the Augmented Dickey-Fuller (ADF) and Phillips-Perron (PP) unit root approaches. The essence of the ADF is to test the null hypothesis of unit root or non-stationary stochastic process. To reject this, the ADF statistics must be more negative than the critical values at 1%, 5% & 10% significance levels respectively. On the other hand, the PP test differs because it provides a more robust test for serial correlation and time dependent heteroskedasticities of the stochastic process.

Table 3 below presents the results of ADF and PP test statistics for the levels and first differences of the stochastic time series data for the period, 1970 - 2013. The asterisk (*) denotes rejection of the unit root hypothesis at the 5% level, while the asterisk (**) denotes rejection of the unit root hypothesis at the 1% level respectively. Note that while the ADF statistics were generated with a test for a random walk against stationary AR (1) with drift and trend with maximum lag of 9, the PP test uses the automatic bandwidth selection technique of Newey-West.

TABLE 3: Unit Root Analysis

VARIABLE	ADF			PP		
	LEVEL	1^{ST} Diff,	Diff. Prob.	Level	1^{st} Diff.	Diff. Prob.
CO_2	-3.374539**	-7.806287**	0.0000	-3.421453**	-7.916308**	0.0000
GDP	-2.954521**	-5.437930**	0.0000	-2.923873**	-5.441683**	0.0000
FFC	-5.630984**	-8.799957**	0.0000	-5.639392**	-13.43575**	0.0000
IND	-4.010901**	-8.082815**	0.0000	-4.030010**	-8.150908**	0.0000
URB	-4.605880**	-6.830746**	0.0000	-3.216325**	-4.155395**	0.0110
TRD	-1.130782	-7.922246**	0.0000	-2.290781*	-7.688556**	0.0000

As indicated by the unit root result, a good number of variables are not integrated, meaning that they are stationary in level. In fact, the ADF and PP values in level suggested that the CO_2 emissions - metric tons per capita (CO_2), fossil fuel energy consumption - % of total (FFC), GDP per capita growth - annual % (GDP), urbanization and (URB), industrialization (IND) are all integrated of order zero ($\Delta = 0$). This leaves only the trade openness (TRD) being integrated of order one ($\Delta = 1$).

The evidence that most of the variables are not integrated did not rule out the fact that a possible long-run linear combination may exist between fossil fuel consumption, CO_2 emissions and economic growth variables since they are of the same order. A prerequisite for the presence of long-run linear combination among them, hence a Johansen cointegration test is carried on to ascertaining the number of integrating vectors that might be present in the model.

This test seeks to identify the number of co-integrating relationships that exist in the model. The study adopted the co-integration method developed by Johansen (1991), popularly called the Johansen co-integration test or cointegration rank test. This test identifies the number of stationary long-run relationships that exist among the set of integrated variables. It offers two tests, the Trace test and the Max-Eigenvalue test. The trace statistic show the null hypothesis that there are at most r number of co-integrating relationships among the variables. Therefore, a rejection of the null hypothesis means that there are more than r numbers of co-integrating relationships. On the other hand, the null hypothesis associating to the Max-Eigenvalue is rejected when the Max-Eigenvalue statistic value exceeds the critical value at every level of r (see table 4).

TABLE 4: Johansen Co-integration Analysis

Hypothesized No. of CE(s)	Eigenvalue	Trace Statistic	0.05 Critical Value	Prob.**
None *	0.727020	134.8734	95.75366	0.0000
At most 1 *	0.540562	80.34236	69.81889	0.0057
At most 2	0.457971	47.67681	47.85613	0.0520
At most 3	0.260465	21.95451	29.79707	0.3010
At most 4	0.171354	9.281681	15.49471	0.3400
At most 5	0.032490	1.387247	3.841466	0.2389

*(**) denotes rejection of the hypothesis at the 5% (1%) level

Trace test indicates 2 cointegration equation(s) at the 5% level. This evidence was reached from the results, which show that up to 2, the trace statistic values are less than 5% critical value. Thus, to further confirm this result, the maximum eigenvalue statistic result is presented. Normally this approach tests the null hypothesis of r versus r+1 co-integrating relationships. The null hypothesis is rejected when the max-eigenvalue test statistics exceeds the respective critical value. Column 2 of table 5 presents the results from this test.

TABLE 5: Maximum Eigenvalues Co-integration Result

Hypothesized No. of CE(s)	Eigenvalue	Max-Eigen Statistic	0.05 Critical Value	Prob.**
None *	0.727020	54.53106	40.07757	0.0006
At most 1	0.540562	32.66555	33.87687	0.0692
At most 2	0.457971	25.72229	27.58434	0.0849
At most 3	0.260465	12.67283	21.13162	0.4828
At most 4	0.171354	7.894434	14.26460	0.3895
At most 5	0.032490	1.387247	3.841466	0.2389

*(**) denotes rejection of the hypothesis at the 5% (1%) level

The Max-eigenvalue test indicates 1 cointegrating equation at the 5% level. The normalized cointegrating coefficients indicated further that the one cointegrating vector or variable is trade openness (TRD). Thus, having established that long-run relationship exist among this variables, we go further to examining their long-run causality relationships using VAR Granger Causality (Block Exogeity Wald Test) approach.

The study adopted the VAR Granger Causality/Wald test approach, suggested by Toda-Yamamoto to estimate the causality relationship between fossil fuel consumption, CO_2 emission and economic growth. This approach computes statistic that asymptotically has a chi square (χ^2) distribution irrespective of the order of integration properties of the variables. The lag length is selected based on Akaike Information Criteria (AIC) and Schwarz Information Criterion (SIC). The summarized Wald Tests result is presented in table 6 below.

TABLE 6: Summary Result of VAR Granger Causality/Block Exogeneity Wald Tests

	Excluded	FFC	GDP	IND	TRD	URB	All
Dep. Var. CO_2	Chi-sq	2.919229	1.625862	5.182237	1.614198	4.125249	17.81591
	Df	2	2	2	2	2	10
	Prob.	0.2323	0.4436	0.0749	0.4462	0.1271	0.0581
	Excluded	CO_2	GDP	IND	TRD	URB	All
Dep. Var. FFC	Chi-sq	0.115578	1.218597	3.479705	0.506421	0.852102	7.096234
	Df	2	2	2	2	2	10
	Prob.	0.9438	0.5437	0.1755	0.7763	0.6531	0.7163
	Excluded	CO_2	FFC	IND	TRD	URB	All
Dep. Var. GDP	Chi-sq	0.459622	0.197829	5.796604	0.187526	5.524576	15.22533
	Df	2	2	2	2	2	10
	Prob.	0.7947	0.9058	0.0408	0.9105	0.0531	0.1241
	Excluded	CO_2	FFC	GDP	TRD	URB	All
Dep. Var. IND	Chi-sq	10.93208	17.20103	2.773913	0.466504	0.795888	30.58235
	Df	2	2	2	2	2	10
	Prob.	0.0042	0.0002	0.2498	0.7920	0.6717	0.0007
	Excluded	CO_2	FFC	GDP	IND	URB	All
Dep. Var. TRD	Chi-sq	0.377069	2.221261	1.803021	2.262599	1.881250	10.42999
	Df	2	2	2	2	2	10
	Prob.	0.8282	0.3294	0.4060	0.3226	0.3904	0.4036
	Excluded	CO_2	FFC	GDP	IND	TRD	All
Dep. Var. URB	Chi-sq	18.08056	10.41132	2.401495	2.642906	6.886689	34.82355
	Df	2	2	2	2	2	10
	Prob.	0.0001	0.0055	0.3010	0.2667	0.0320	0.0001

EViews estimate

The result is computed in six (6) quadrants, each showing how the explanatory variables granger causes the dependent variable in that quadrant. In the first quadrant, the result showed that CO_2 emission does not granger caused by any of the endogenous variables modeled in that equation. This is because, at 5% level of significant, none of the probability value is less than 0.05 in absolute term. However, the result indicated that all the variables (FFC, GDP, IND, TRD and URB), on aggregate, granger causes CO_2 emission. In the second quadrant, fossil fuel consumption (FFC) is caused by from other endogenous variables. But the evidence from the result shows that none of the endogenous variables included in that equation, granger causes the total percentage of fossil fuel consumption in Nigeria. Also all the variables put together still have no cause link to fossil fuel consumption.

The next, in the third quadrant, is the dependent of economic growth to causal relationships of other endogenous variables. Evidence from the result indicated that neither fossil fuel consumption none economic growth granger causes economic growth in Nigeria. The variables shown to be causing economic growth are rate of industrialization and urbanization in Nigeria. However, there exists no feedback causal relationship between economic growth, industrialization and urbanization, the direction of relationship proved that economic growth is at the receiving ends. Although, the result in the fourth and the sixth quadrants indicated that the percentage rate of fossil fuel consumptions granger cause both industrialization and urbanization rates in Nigeria. Another variable that show to granger cause urbanization rate in Nigeria is the trade openness. The result also indicated that all the endogenous variables put together granger causes industrialization and urbanization rates. On the fifth quadrant, the result shows that none of the endogenous variables in the model granger causes trade openness in Nigeria. While in the last quadrant, it indicated that CO_2, FFC and TRD granger causes urbanization, and on aggregate, all the variables granger cause URB.

In summary, evidence from the result shows that neither economic growth (GDP) that granger cause CO_2 nor CO_2 granger cause GDP. Therefore, there is no causality relationship between CO_2 and GDP in Nigeria. Also established from the result is that there is no causality relationship between CO_2 and fossil fuel consumption in Nigeria. Even fossil fuel consumption and economic growth has no granger causality relationship. The only established causality relationship in our result is between industrialization and economic growth and urbanization and economic growth, all having unidirectional causality links. That is, industrialization causing GDP and urbanization causing GDP, without GDP granger causing any of them. Also, CO_2 and FFC granger causes industrialization, but no reverse causality relationships between them. In a similar manner, CO_2 and FFC granger causes urbanization, but no reverse causality relationships between them. Another variable that indicated to granger cause urbanization is trade openness (TRD), with no reverse causal links between both of them.

Although, the aim of this analysis is trace possible long-run causality relationships among fossil fuel consumption (FFC), carbon emissions captured by CO_2 emission (CO_2) and economic growth captured with GDP per capita growth rate (GDP). So far, there is no evidence of long-run causality relationship among them.

CONCLUSION

The paper estimated the causal links among fossil fuel energy consumption, carbon emissions and economic growth in Nigeria. For effective estimation, the VAR Granger Causality (Block Exogeneity Wald Tests) approach was adopted. The result of the analysis leads to the discovery of some interesting facts. The study found no significant long-run causal links among economic growth, fossil fuel energy consumption and CO_2 emission in Nigeria. This implies that the long-run relationships among fossil fuel consumption, carbon emissions and economic growth established earlier in the cointegration analysis do not translate into causality. The only causal relationship established in the study was a unidirectional causality from CO_2 emission and fossil fuel consumption to industrialization and from trade openness to urbanization rate which were included in the model as control variables. This implies that no policies relating to fossil fuel energy and carbon emissions in Nigeria will have any effect on economic growth. Therefore, Nigeria should pay adequate attention to the environmental impact of fossil fuel energy and substitute fossil fuel with alternative energy that has less carbon emissions, as the implication of such policy will not retard economic growth in Nigeria.

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