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The Causality between Energy Consumption, Co_2 Emissions and Economic Growth in Nigeria: An Application of Toda and Yamamoto Procedure

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ABSTRACT

This paper investigated the relationship between energy consumption, carbon dioxide (CO_2) emissions and economic growth in Nigeria using using modified version of granger causality test suggested by Toda and Yamamoto. The empirical result of the causality test indicates unidirectional causality running from CO_2 emissions to economic growth; energy consumption to CO_2 emissions and bi-directional causality between energy consumption and economic growth. This suggests that any effort to lower the problem of CO_2emissions by reducing energy consumption could negatively affect economic growth. We therefore, suggested that renewable source of energy such as solar and wind could be explored and considered as an alternative source of energy since Nigeria is well endowed with solar energy. This will assist in reducing CO_2 emissions and at the same time sustaining long run economic growth.

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INTRODUCTION

Global warming and climate change have been the topical issues in climatology, environmental science, environmental economics, in the recent years owing to the devastating effects of the former on the latter. Thus, greenhouse emissions have been constantly increasing due to human activities, energy consumption, and fossil fuel combustions, etc. The pursuance of growth targets has made so many countries to involve in industrial production that requires higher energy consumption. However, among the components of greenhouse emissions, carbon dioxide (CO_2) emissions has been regarded as the major contributor with about more than 60% of the total of green gases (Kaygusuz, 2009). International organizations such as the United Nations have made efforts to cut down the hostile effects of global warming and climatic changes through governmental binding agreements, for example Kyoto Protocol (Halicioglu, 2009). This is a protocol to the United Nations Framework Convention on Climate Change (i.e. UNFCCC), which seek to reduce global warming. The major goal of this protocol is to achieve stabilized greenhouse gas concentrations in the atmosphere. It was founded in 1997 in Kyoto, Japan; however, the agreement was re-validated with actions in 2005. As of June 2013, there were 192 parties to this protocol who have ratified it. Nigeria as a party to this agreement ratified it on December 10, 2004 as 130th member.

Climate models suggest that climate in Africa will be more variable with a high degree of uncertainty about its projections in Sahel zone. The West Africa's temperature especially, the Sahel zone has raised significantly than the global trend (PACJA, 2009). In the case of Nigeria, it is predicted that there may be a rise in sea level up to 0.3m by 2020 and also 1m by 2050, and temperature may rise up to 3.2^0 C by 2050 (DFID, 2009). The predicted rise of 1m may lead to the loss of 75% of the Niger Delta region through flooding. PACJA (2009) further asserted that by 2020, if no measure is taken, about 2% to 11% of Nigeria's GDP may be potentially lost. Nigeria's average growth has been around 6% since the last decade. Despite this remarkable development, the supply of electricity which is supposed to be the main source of energy in Nigeria is epileptic. This has therefore necessitated a shift from electricity usage to other alternative sources of power that requires the burning of fossil fuels. This thereby leads to an increase in toxic emissions.The energy consumption index in Nigeria increased from 2.8% in 2010 relative to the index in 2009 which was put at 1.9%.Consequently, emissions of greenhouse gases have also increased. To sum it, the average change of pollutants emitted between 1990 and 2009 was put at 41.3% which has growing negative effect on climatic condition and subsequently accelerates global warming. Therefore, climate change has now become a development issue rather than just an environmental issue, which threatens the sustainable development of Nigeria. It is against this background that this study aims to ascertain

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the relationship between energy consumption, CO_2 emissions and economic growth in Nigeria using an ARDL approach to cointegration.

The remainder of this study is organized as follows. Section 2 discusses the empirical literature on the relationship between economic growth, CO_2 emissions and energy consumption. Section 3 presents the data and methodology used in the study. Section 4 discusses the empirical findings, and the conclusion and policy implications are included in Section 5.

Literature Review:

Several studies have been conducted in this area to ascertain the relationship and the causal relationship between energy consumption and economic growth or energy consumption, CO_2 emissions and economic growth. For instance, Kraft (1978) is regarded as the pioneer author to investigate the relationship between energy consumption and economic growth in United States over the period of 1947 to 1974. Thereafter, empirical studies followed with different methods of analysis. Ang (2007) investigated the relationship between CO2 emissions, energy consumption and output in France and reported that there exists significant long run relationship among these variables.

Acaravci and Ozturk (2010) examined the causal relationship between carbon dioxide emissions, energy consumption and economic growth using autoregressive distributed lag (ARDL) bounds testing approach of cointegration and error-correction based Granger causality models for nineteen European countries for period 1960-2005. They found evidence of a long-run relationship between carbon emissions per capita, energy consumption per capita, real GDP per capita and the square of per capita real GDP only for Denmark, Germany, Greece, Iceland, Italy, Portugal and Switzerland. Despite that, there is a long-run unidirectional causal relationship in those countries.

Alam *et al*. (2011) investigate the causality relationships among energy consumption, carbon dioxide emissions and income in India by adopting a dynamic modeling approach. By utilizing an innovation accounting method to investigate profiles of the macroeconomic variables persisting from an unanticipated shock in innovation, there is an evidence of the existence of bi-directional Granger causality between energy consumption and carbon dioxide emissions in the long run. But neither carbon dioxide emissions nor energy consumption causes movements in real income. There is no causality relationship between energy consumption and income in any direction in the long run.

Arouri *et al*. (2012) investigate the relationship between carbon dioxide emissions, energy consumption, and real GDP for 12 Middle East and North African Countries (MENA) over the period 1981-2005. Employing recent bootstrap panel unit root tests and cointegration techniques, they found that in the long-run energy consumption has a positive significant impact on carbon dioxide emissions and more interestingly real GDP exhibits a quadratic relationship with carbon dioxide emissions for the regions as a whole.

Bloch *et al*. (2012) investigate the relationship between coal consumption and pollutant emission both in short-run and long-run in China by applying both supply side and demand side frameworks using data period from 1977-2008 and 1965-2008. Under a supply side analysis, there is a unidirectional causality running from coal consumption to output in both short run and long run. While there is also a unidirectional causality running from income to coal consumption in the short run and long run under the demand side analysis. The results also reveal that there is a bi-directional causality between coal consumption and pollutant emission both in the short and long run.

Alkhathlan and Javid (2013) examine the relationship between economic growth, carbon emissions and energy consumption at the aggregate and disaggregate levels in Saudi Arabia over the 1980-2011 periods. The findings are long term income elasticity of carbon emission in three of four models are positive and higher than estimated short term income elasticity. The results suggest that carbon emission increase with the increase in per capita income which supports the belief that there is a monotonically increasing relationship between per capita carbon emissions and per capita income for the aggregate model and for the oil and electricity consumption models. Besides that, the long and short term income elasticity of carbon emissions is negative for the gas consumption models.

Ozturk and Acaravci (2010) examined the long run and short run causal relationship between economic growth, carbon emissions, energy consumption and employment ratio in Turkey using ARDL bounds testing approach to cointegration over the period of 1968-2005. Their findings indicated an evidence of long run relationship between the variables at 5% significance level and the estimated results for the existence and direction of causality revealed that neither carbon emissions per capita or energy consumption per capita cause real GDP per capita, but employment ratio causes real GDP per capita in the short run. They therefore concluded that energy conservation policies such as rationing energy consumption and controlling carbon dioxide emissions have no adverse effect on real output.

Menyah and Wolde-Rufael (2010) investigated the long run and causal relationship between economic growth, pollutant emissions and energy consumption in South Africa for the period of 1995-2006. By employing bounds testing approach to cointegration, the results revealed long run relationship among the variables. The further applied modified Granger causality test which show unidirectional causality running from pollutant emission to economic growth; from energy consumption to growth and from energy consumption to CO2 emissions.

Lotfalipour *et al*. (2010) investigated the causal relation between economic growth, carbon emissions and fossil fuels using Toda-Yamamoto causality test method in the case of Iran over the period of 1967 to 2007. They reported that unidirectional Granger causality runs from GDP and energy consumption to carbon emissions. They further indicated that carbon emissions and energy consumption do not lead to growth.

Azhar Khan *et al*. (2013) explored the causal relationship between greenhouse emission, growth and energy consumption using cointegration and Granger causality test in Pakistan during 1975 to 2011. Their findings reveal that energy consumption serves as an important driver of CO_2 emissions and also indicated unidirectional causality running from energy consumption to CO_2 emissions.

Jahangir *et al*. (2012) examined the possible dynamic causality between energy consumption, carbon emissions and economic growth in Bangladesh using cointegration test and granger causality test. Unidirectional causality was reported from energy consumption to economic growth, unidirectional causality from energy consumption to CO_2 emissions and CO_2 emissions granger cause economic growth.

Methodology And Data:

Despite the fact that the interrelationships between environmental pollution, capital accumulation and other growth variables are important in growth theory (Xepapadeas, 2005), there few studies which have investigated the causal relationship between economic growth, energy consumption and pollutant emissions that include labor and capital. Most previous studies employed model of only these three variables and some with the addition of employment ratio as a control variable. However, recently there have been few studies that have highlighted the importance of energy consumption and emissions as additional variables to traditional growth theory model to examine their impact on economic growth (see Menyah and Wolde-Rufael, 2010; Ang, 2008, 2009; Soytas, 2007; Zhang and Cheng, 2009). In this paper, following these authors, we employ granger non-causality test developed by Toda and Yamamoto (1995) to investigate the long run and the causal relationship between CO_2 emissions, energy consumptions, labour and capital in the case of Nigeria over the period of 1970 to 2010.

Granger Non-causality Test:

In order to estimate our model, we have employed Granger non-causality test using Toda and Yamamoto (1995) procedure. Toda and Yamamoto procedure for testing granger causality is appropriate and valid in any case, whether the series are purely I(0), I(1) or I(2), cointegrated or not cointegrated. The unique feature of T-Y procedure is that it does not require pre-testing for cointegrating properties of the system and therefore avoids the potential bias being associated with unit root test and cointegration test since it could be applied irrespective of whether the series are I(0), I(1) or I(2) and whether the series are cointegrated or not cointegrated of an arbitrary order (see Menyah and Wolde-Rufael, 2010; Rambaldi and Doran, 1996). T-Y 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. As stated earlier, T-Y approach uses a modified wald test (MWALD) for restrictions on the parameter of VAR (k, i.e. the lag length of the system). In this process, T-Y approach artificially augment the lag order (k) by the a mximun order of integration, d_{max}, i.e $(k+ d_{max})^{th}$. Then, $(k+ d_{max})^{th}$ order of VAR is estimated. In our own case, to test T-Y non-granger causality, we use VAR with 5 lags (k=4, d_{max}=1). Thus, the following system of equations are estimated:

$$\begin{bmatrix} \ln Y_t \\ \ln L_t \\ \ln K_t \\ \ln CO_t \\ \ln EC_t \end{bmatrix} = A_0 + A_1 \begin{bmatrix} \ln Y_{t-1} \\ \ln L_{t-1} \\ \ln K_{t-1} \\ \ln CO_{t-1} \\ \ln EC_{t-1} \end{bmatrix} + A_2 \begin{bmatrix} \ln Y_{t-2} \\ \ln L_{t-2} \\ \ln K_{t-2} \\ \ln CO_{t-2} \\ \ln EC_{t-2} \end{bmatrix} + A_3 \begin{bmatrix} \ln Y_{t-3} \\ \ln L_{t-3} \\ \ln K_{t-3} \\ \ln CO_{t-3} \\ \ln EC_{t-3} \end{bmatrix} + A_4 \begin{bmatrix} \ln Y_{t-4} \\ \ln L_{t-4} \\ \ln K_{t-4} \\ \ln CO_{t-4} \\ \ln EC_{t-4} \end{bmatrix}$$

$$+ A_5 \begin{bmatrix} \ln Y_{t-5} \\ \ln L_{t-5} \\ \ln K_{t-5} \\ \ln CO_{t-5} \\ \ln EC_{t-5} \end{bmatrix} + \begin{bmatrix} \xi_{\ln Y_t} \\ \xi_{\ln L_t} \\ \xi_{\ln K_t} \\ \xi_{\ln CO_t} \\ \xi_{\ln EC_t} \end{bmatrix} \qquad (1)$$

Where A_1…….. A_5 are 6 x 6 matrices of coefficients with A_0 being 5x1 identity matrix and ξ_s are the disturbance terms which are assumed to have zero mean and constant variance. To test the hypothesis that CO_2 emissions *($lnCO_t$)* does not granger cause economic growth *(lnY_t)*, we use the following hypotheisis: $H_o : a_{ij}^1 = a_{ij}^2 = a_{ij}^3 = a_{ij}^4 = a_{ij}^5 = 0$. Where a_{ij}'$_s{}^i$ are the coefficients of CO_2 emissions ($lnCO_t$) in equation 8.

Also, to test for opposite non causality from economic growth (lnY_t) to CO_2 emissions ($lnCO_t$), we use the following null hypothesis: $H_o : a_{ji}^1 = a_{ji}^2 = a_{ji}^3 = a_{ji}^4 = a_{ji}^5 = 0$. Where $a_{ji's}^{i}$ are the coefficients of economic growth variables in equation 8. Similar procedures are applied to testing causality between other variables in the equation.

RESULTS AND DISCUSSION

Unit Root Test Results:

Application of Toda and Yamamoto procedure does not formally require pre-testing of variables for unit root. As whether all the variables are I(0), I(1) I(2) or mixture, it does not matter. But for the purpose of identifying each variable's order of integration, we employed Augmented Dickey Fuller (ADF) and Phillips Perron (PP) to test for the order of integration of the series. The results of these tests (Table 1) shows that energy consumption and labor were I(0) whereas economic growth, CO_2 emissions and capital are I(1). In view of this results of having mixture of order of integration among the series,Toda and Yamamoto procedure is more appropriate to be applied than any other methods of testing causality.

Table 1: Unit Root test using Augmented Dickey Fuller (ADF) and Phillips Perron (PP).

Variables	Level				First Difference			
	ADF		PP		ADF		PP	
	Constant	Constant & trend	Constant	Constant & trend	Constant	Constant & trend	Constant	Constant & trend
lnY_t	-0.78 (0.811)	-0.96 (0.937)	-1.21 (0.658)	-1.39 (0.848)	-4.95*** (0.000)	-4.91*** (0.001)	-4.92*** (0.000)	-4.88*** (0.001)
$lnCO_t$	-1.98 (0.291)	-2.53 (0.309)	-1.98 (0.289)	-2.53 (0.309)	-6.77*** (0.000)	-6.68*** (0.000)	-6.89*** (0.000)	-6.73*** (0.000)
$lnEC_t$	-4.91*** (0.000)	-3.29* (0.081)	-4.87*** (0.000)	-3.49* (0.053)	-4.50*** (0.000)	-5.25*** (0.000)	-4.46*** (0.001)	-5.24*** (0.000)
lnK_t	-2.48 (0.12)	-2.87 (0.181)	-1.89 (0.330)	-2.19 (0.477)	-4.63*** (0.000)	-4.57*** (0.004)	-4.81*** (0.000)	-4.66*** (0.003)
lnL_t	-5.29*** (0.000)	-5.65*** (0.000)	-1.97 (0.297)	-1.91 (0.630)	-3.09** (0.037)	-2.00 (0.576)	-1.45 (0.546)	-0.98 (0.933)

Note: ***,**, and * denote significant at 1%, 5% and 10% levels respectively.

Granger Causality Test Results:

To avoid getting spurious causality results such as having spurious presence of causality or spurious absence of causality, in addition to identifying the order of integration of the variable, it is vital to ascertain the optimal lag length(k) in equation 1. Granger causality test could be highly sensitive to lag selection. If the selected lag length is lower than the true lag, the omission of the relevant lags may cause bias in the results. Conversely, if the selected lag length is greater than the true lag, the irrelevant lags in the equation will cause the estimates to be inefficient (Clarke and Mirza, 2006; Menyah & Wolde-Rafael, 2010). Following previous literatures, we employed a combination of Akaike Information Criterion (AIC), Schwarz Bayesian Criterion (SBC), Likelihood Ratio (LR) and other lag selection criterions. However, all the criterions suggested lag 4 as the optimal lag. We further applied diagnostic tests to our chosen lag make sure that we have a better model which includes serial correlation test, normality test and heteroskedasticity test. The results of these tests (Table 2) points out that the Vector Autoregression (VAR) system is generally free from serial correlation, heteroskadasticity and abnormality of the error terms. Therefore, we found no evidence of violation of classical linear regression model assumptions.

Table 2: VAR diagnostic tests' results.

Variable	Serial Correlation LM tests: A	Normality Test: B	Heteroscedasticity Test: C
lnY_t	30.201 [0.216]	0.527 [0.768]	0.740 [0.741]
$lnCO_t$	35. 498[0.079]*	0.276 [0.870]	1.099 [0.425]
$lnEC_t$	16.171 [0.909]	1.908 [0.385]	2.116 [0.061]*
lnL_t	31.891 [0.161]	0.111 [0.944]	1.850 [0.102]
lnK_t	21.994 [0.636]	0.770 [0.680]	0.730 [0.751]

Note: ***, **, and * are significant at 1%, 5% and 10% respectively.

A: langrange multiplier test of residual serial correlation
B: Based Jarque-Bera test
C: VAR resudual Heteroscedasticity test

The next step is to estimate the T-Y granger non-causality test by augmenting our VAR with the maximun order of integration of the series (d_{max}). The results of this test are presented in Table 3. Based on the objective of this paper, we are going to be concerned about the results of the relationship between GDP, CO_2 emmisions and energy consumption. As we could see from the table 7, there is a causality running from CO_2 emissions to economic growth without feedback. This result supports our earlier long run findings in Table 3 where CO_2

emissions have a positive impact on economic growth. It is also consistent with empirical evidence reported by Ang (2008) for Malaysia and Zhang and Cheng (2009)in the case of China. This implies that a reduction in CO_2 emissions may lower economic growth. There is also unidirectional causality running from energy consumption to CO_2 emissions without feedback as well, suggesting that an increase in energy consumption facilitates CO_2 emissions. This is in line with the view that energy consumption is the main cause environmental degradation CO_2 emissions and also consistent with empirical evidence by Lotfalipour *et al*. (2010) reported for Iran and, Azhar Khan *et al*. (2013) who reported similar results for Pakistan. This is true because, Nigeria heavily depends on fossil fuel as a source of its energy for industrial and other productive activities. Furthermore, there exists bidirectional causality between energy consumption and economic growth. That is, higher consumption leads to higher economic growth and higher economic growth also leads to higher energy consumption, consistent with empirical findings by Jahangir *et al*. (2012) in the case of Bangladesh. The finding implies that Nigeria economic growth depends on the level of energy usage in the country.

Table 3: Toda and Yamamoto Granger Non-causality Test Results.

Null hypothesis	χ^2	*p*-value
CO_2 does not cause GDP	9.27	0.05*
GDP does not cause CO_2	6.89	0.14
Energy does not cause GDP	17.64	0.00***
GDP does not cause energy	14.90	0.00***
CO_2 does not cause energy	7.21	0.11
Energy does not cause CO_2	11.64	0.02**
Capital does not cause GDP	2.63	0.62
GDP does not cause Capital	34.26	0.00***
Labour does not cause GDP	6.08	0.19
GDP does not cause labour	0.70	0.95

Note: ***, **, and * are indicates significant at 1%, 5% and 10% levels respectively

Conclusions And Policy Recommendation:

As a party to kyoto protocol to United Nations Framework Convention on Climate Change (UNFCCC), Nigeria is facing a challenge on how to use fossil fuel in a way that will not increase CO_2 emissions. Therefore, it is confronted with the crucial decision of balancing of fossil fuel consumption and reducing green house gases emissions.

This paper investigated the causal relation between energy consumption, CO_2 emissions and economic growth in Nigeria over the period of 1971-2010 using modified version of granger causality test suggested by Toda and Yamamoto (1995). The empirical results of T-Y causality test indicates unidirectional causality running from CO_2 emissions to economic growth; energy consumption to CO_2 emissions and bi-directional causality between energy consumption and economic growth. These empirical evidences suggest that an attempt to reduce CO_2 emissions by reducing fossil fuel consumption will lower economic growth. As such, alternative sources of energy with least CO_2 emissions need to be explored in order to tackle emission issue and at the same time not sacrificing economic growth.

The policy recommendation that could be deduced from the empirical evidence is that Nigeria should as part of its ongoing transformation program, green its energy policies and also diversify into other alternative energy sources with less greenhouse gas emission. Renewable energy sources specifically solar and wind may be considered since Nigeria is well endowed with solar energy. This will assist in reducing CO_2 emissions and at the same sustaining long run economic growth.

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