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An Econometric Study of Co_2 Emissions, Energy Consumption, Foreign Trade and Economic Growth in Nigeria.

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Abstract

This paper provides a detailed analysis of 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 which includes labour and capital as additional/control variables. An augmented form of Granger causality and the bounds testing approach to co-integration which is based on Autoregressive Distributed lag (ARDL) procedure proposed by Pesaran et al (2001) were employed to test t he interrelationship between the variables. The bounds test result indicates that economic growth is determined by energy consumption, carbon emissions, capital and foreign trade. The result from the modified Granger causality test reveals 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 foreign trade to economic growth .The empirical results also provide evidence that expansion in international trade increases CO_2 emissions indicating that foreign trade is harmful to environmental quality in Nigeria. Important policy recommendations are also provided.

Keywords: Co_2 Emissions, economic growth, foreign trade, energy consumption, bounds testing, Environmental Kuznets Curve.

31.1 Introduction

At present, all over the world the production and consumption of energy is mostly based on non-sustainable technologies which will not be tolerated in future because of its negative consequences for human survival. World-wide organizations such as the United Nations in an attempt to reduce the adverse impacts of climate change had through the Kyoto protocol of 1997 and the United Nations Climate Change Conference at Copenhagen in 2009 reached a consensus on legal binding of green house gas (GHG) emission reduction to preserve the environment for present as well as future generations and make the economy more sustainable .The Nigerian economy is heavily dependent on the oil sector which accounts for over 95 percent of export earnings and about 85 percent of government revenues. Nigeria is an energy intensive growing economy. Like most oil- depended economy, it is confronted with the crucial issue of producing more oil to meet its energy requirements, while at the same time grappling with the issue of reducing greenhouse gas (GHG) emissions. Concerns over increases in the price of oil relative to other energy sources and oil reserves exhaustion have further complicated the issue.

Against this background, it is therefore imperative to understand the interrelationship among energy consumption, economic growth, carbon emissions and foreign trade in Nigeria. Over the years, researchers have carried out a plethora of researches on the causal relationships between economic growth and energy consumption as well as economic growth and environmental quality which is referred to as *Environmental Kuznets Curve Hypothesis* (EKC). The EKC hypothesis conjectures that environmental degradation initially intensifies when a country's per capita income increases and subsequently subsides after a certain level of income is reached, resulting in an inverted U-shaped relationship between environmental degradation and per capita income. The World Bank (1992) explains that this hypothesis is based on the existence of positive income elasticity for environmental quality, or in other words, that the demand for environmental quality increases as a country becomes more developed. This hypothesis was first proposed and tested by Grossman and Krueger (1991). Other researchers on the economic growth and environmental pollution nexus include Stern (2004) and Dinda (2004), Shafik (1994), Heil and Selden (1999), Friedl and Getzner (2003), Dinda and Coondoo (2006), Coondoo and Dinda (2008), and Managi and Jena (2008)., Lucas et al. (1992), Wyckoff and Roop (1994), Suri and Chapman (1998), and Nohman and Antrobus (2005). The empirical results, however, appear to be inconclusive.

On the energy consumption-growth nexus, the argument has focused on whether economic growth responds to increase in energy consumption or whether increase in economic growth actually stimulates energy consumption. This area of study which has been researched extensively with a number of empirical works, also present inconclusive evidence. Examples of this line of research starts with the seminal study of Kraft and Kraft (1978).Others include Masih and Masih (1996), Yang (2000), Wolde-Rufael (2006), Narayan and Singh (2007), Narayan et al. (2008), and Omisakin (2009)

The relationship between environmental quality and international trade has its root in the Hecksher-Ohlin trade theory which states that countries are endowed with different factor supplies, resulting in different relative factor prices (e.g. labour will be relatively cheap in labour abundant countries) and so too will domestic commodity price ratios and factor combinations. Countries with cheap labour will have a relative cost and price advantage over countries with relatively expensive labour in commodities that make intensive use of labour e.g. primary products. Trade openness provides a way for mobilizing factors of production freely between countries thereby enhancing production intensively by utilizing abundant domestic resources efficiently. However, movement of factors of production may also move dirty industries from home countries to developing economies where laws and regulations about environment are not stringent.

Though some researches on the energy-environment- growth linkage in Nigeria has been carried out by some Nigerian authors (for instance, see Omisakin (2009), Akpan and Chuku, (2011), Iwayemi and Adenikinju (2001), Jerome A. (2001), Garba A. and Garba P. (2001), only Chukwu and Ndifreke (2011) have carried out a study which centered on energy- environment ï trade-growth linkage in Nigeria using a combined simultaneous approach. Moreover, most of these studies mainly focus on testing the validity of the so-called Environmental Kuznet's Curve and do not consider investigating the causal relationship between energy consumption, carbon emissions and economic growth in the same framework. The aim of this study is to show how environmental degradation and other crucial variables such as energy and foreign trade combine with capital and labour to affect the growth process using a coherent framework. Since fossil-fuel energy use is the main source of global warming, incorporating energy consumption and other growth determining factors such as labour and capital in the same growth accounting framework can enhance our understanding of the issues that can affect global warming We include these additional variables because the exclusion of relevant variables makes the estimates not only biased but also inconsistent, but the absence of causality in a bivariate system can arise from omitted variables (Lütkepohl, 1982). However, since a six-variable case incorporates more information, the causal inference drawn may be relatively more reliable (Loizides and Vamvoukas, 2005).

This paper attempts to establish the long-run relationship between the variables by using the cointegration procedure developed by Pesaran et al. (2001), hereafter PSS, while testing for causality is conducted using a modified version of the Granger causality test proposed by Toda and Yamamoto(TY)

(1995). To reinforce our empirical findings, we carried out certain sensitivity analysis such as the cumulative sum (CUSUM) and cumulative sum squares (CUSUMSQ) tests proposed by Borensztein, *et al.* (1998), serial correlation test and the normality test, among others, to test the stability of the long-run coefficients.

The remainder of the paper is structured as follows. The next section presents an overview of economic growth, energy consumption and carbon emissions in Nigeria. Section 3 presents the data and methodologies. Section 4 presents the results and discussions while section 5 concludes and draws policy implications.

31.2 Overview of energy consumption, carbon emissions and economic growth in Nigeria.

Nigeria is rich in energy resources and is currently Africaôs largest producer and exporter of petroleum and gas. According to the International Energy Agency (IEA), in 2007, total energy consumption in Nigeria was 4 Quadrillion Btu (107,000 kilotons of oil equivalent). Of this, combustible renewables and waste accounted for 80.2 percent of total energy consumption. This high percent share represents the use of biomass to meet off-grid heating and cooking needs, mainly in rural areas. The abundant alternative energy resources in the country such as solar and wind are yet to make any significant contributions presently.

According to the World Resources Instituteôs Climate Analysis Indicators Tool (CAIT) results, 54.9% of Nigeriaôs 2005 GHG emissions were produced by activities in the energy sector; 0.5% of the emissions was from the industrial sector; 38.7% of the emissions was contributed by agricultural activities, and 5.9% of the emissions came from waste management as shown in Figure 31.1. Within the profile, the

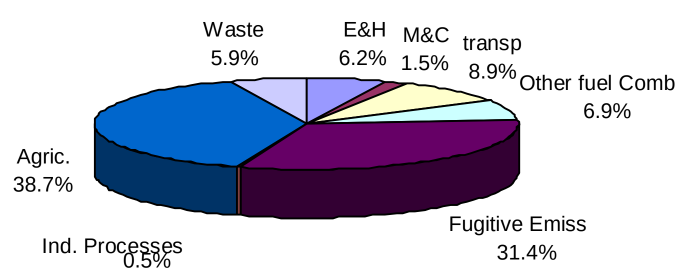

Figure 31.1 GHG Emissions for Nigeria by Sector in 2005
Source: Dayo, et. al (Sept, 2009); óNigeriaôs Perspective on Climate Change Mitigationö, ICEED Working Paper, pg 49, Abuja, Nigeria.

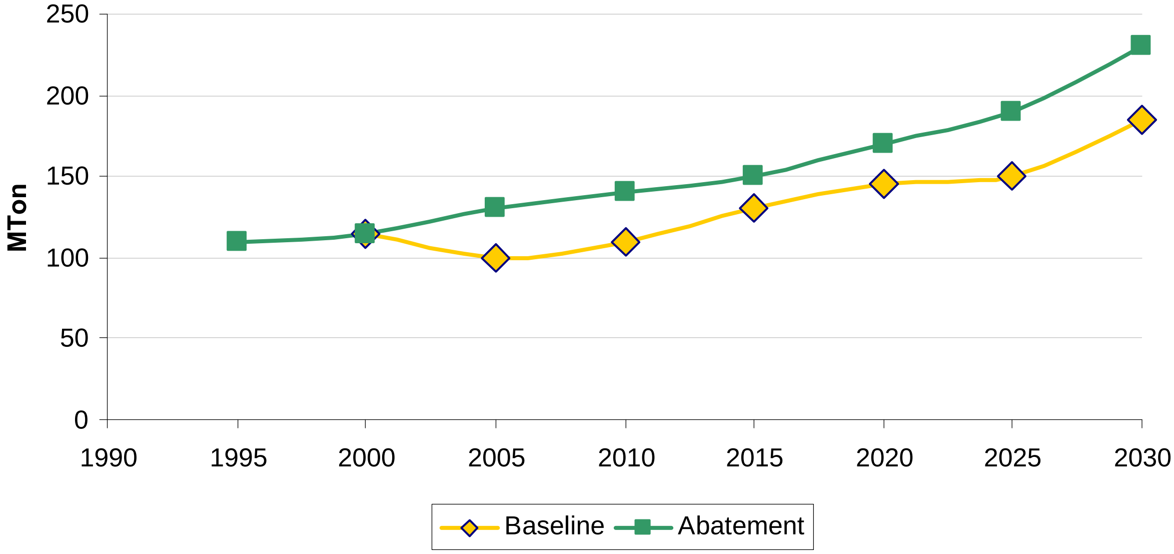

Figure 31.2 : CO_2 Emissions from Energy Sector

Source: Dayo, B; A. Gilau and M. Samec (Sept, 2009); ôNigeriaôs Perspective on Climate Change Mitigationö, ICEED Working Paper pg 52, Abuja, Nigeria.

emission trends show that although CO_2 emissions do not currently make up the majority of Nigeriaôs GHG emissions, they will become more significant as Nigeria becomes more industrialized i.e. demanding more fuel usage. The key drivers of CO_2 emissions are population, economic activity, and the CO_2 intensity of the economy. According to the analysis, it is expected that for the coming 30 years, CO_2 emissions from energy sector will increase exponentially (figure 31.2). This is for the fact that Nigeria has one of the largest populations in the world (over 150 million people) and growing at a high rate- 2.7% on average from 1990 to 2005. The economy is highly dependent on oil export and Nigeriaôs CO_2 intensity of the economy is high (ECN, 2008)

31.3 Methodology

Though it is recognized that the linkage between environmental pollution, trade, capital accumulation and other growth variables are the basic tenets of the growth theory (Xepapadeas, 2005, p. 1221) yet, there are not many studies that have investigated the causal relationship between economic growth, energy consumption and carbon emissions which also include labour and capital in their analysis. This lack of empirical investigation is particularly true for Nigeria. However, a few studies have attempted to highlight the importance of both energy and pollutant emissions as additional variables to capital and labour in the growth process for some countries (see, Ang, 2008, 2009; Sari and Soytas, 2007, 2009; Soytas and Sari, 2009; Apergis and Payne, 2009; and Zhang and Cheng, 2009). In this paper, following some of these authors, we employ the autoregressive distributive lag (ARDL) approach to cointegration test developed by PSS and the Granger causality test proposed by TY to investigate the long-run and the causal relationship among economic growth, energy consumption, CO_2 emissions, foreign trade, capital and labour in Nigeria .

31.3.1 Data source and variable definition.

The study uses annual time series data for Nigeria for the periods 1970-2009, which are mainly from the World Bank country data base (2009), Carbon Dioxide Information Analysis Center, USA, and the Central Bank of Nigeria Statistical Bulletin of 2008, 2009 and 2010. The variables used are real GDP [(Y_t) proxy for economic growth]; total energy consumption [(E_t) measured in million tons of oil equivalent], total carbon dioxide emissions [(CE_t) measured in million metric tons], trade openness (TR_t) [(Imports + exports)/GDP] and two additional variables, total labour force and the gross fixed capital formation (as a proxy for stock of physical capital). All data are converted into natural logarithm. There are some debates in the literature as to whether to use the total or per capita basis data. In a single country study, dividing the variables by the population number only scales the variables down (Soytas et al. (2007) with apparently no other advantage. Friedl and Getzner (2003) further argue that the Kyoto Protocol calls for a reduction in the percentage of emissions from its base of total emissions rather than per capita emissions. Therefore, our study uses aggregate data rather than per capita data to estimate the variables in a multivariate framework.

31.3.2 Time series properties of data

The time series characteristics of the variable are investigated. The purpose is to determine the order of integration because the (ARDL) bounds testing approach to co-integration becomes applicable only in the presence of I(0) or I(1) variables. Thus, the assumption of bounds testing will collapse in the presence of I(2) variable (Fosu et al., 2006). More so, the Todaï Yamamoto (TY) procedure requires the knowledge on the maximum order of integration that the series in concern have. We conduct unit root tests on the variables included in the regression by employing both the Augmented Dickey-Fuller (ADF) and Philips-Peron tests at 1%, 5% and 10% levels of significance. The null hypothesis is that unit root problem exists, that is, Ŭi = б1 = ǝ1 = ι 1 = vi = 1 against the alternative hypothesis that there exists no unit root problem that is, Ŭi Í б1 Í ǝ1 Í ι 1 Í v1 <1.

31.3.3 Bounds test approach to cointegration

The bounds test approach to cointegration has certain econometric advantages in comparison to other single equation co-integration procedures. As pointed out by Emran et al. (2007), the bounds test approach to co-integration is preferred to other conventional cointegration tests because Monte Carlo evidence shows that it has several important advantages over other conventional tests. The approach effectively corrects for a possible endogeneity of explanatory variables and the estimates derived from the approach exhibit desirable small sample properties. Another important advantage of the ARDL approach is that one can avoid the uncertainties created by unit root pre-testing as the test can be applied regardless of whether the series are I(0) or I(1). An added bonus of this approach is that unlike other conventional tests for co-integration, it can be applied to studies that have a small sample size (Narayan, 2005). In addition, both the short- and the long-run relationship can be simultaneously estimated. In this paper the ARDL approach to co-integration is estimated using the following unrestricted error correction (UREC) regressions:

$$\Delta InY_t = \alpha_1 + \sum_{i=1}^{p}\beta_{1i}\Delta InY_{t-i} + \sum_{i=0}^{p}\kappa_{1i}\Delta InCE_{t-i} + \sum_{i=0}^{p}\varpi_{1i}\Delta InE_{t-i} + \sum_{i=0}^{p}\Psi_{1i}\Delta InTR_{t-i} + \sum_{i=0}^{p}\sigma_{1i}\Delta InK_{t-i} + \sum_{i=1}^{p}\xi_{1i}\Delta InL_{t-i} + \eta_{1Y}\, InY_{t-1} + \eta_{2Y}\, InCE_{t-1} + \eta_{3Y}\, InE_{t-1} + \eta_{4Y}\, InTR_{t-1} + \eta_{5Y}\, InK_{t-1} + \eta_{6Y}\, InL_{t-1} + \mu_{1t} \quad \ldots \tag{1}$$

$$\Delta InCE_t = \alpha_2 + \sum_{i=0}^{p}\beta_{2i}\Delta InY_{t-i} + \sum_{i=1}^{p}\kappa_{2i}\Delta InCE_{t-i} + \sum_{i=0}^{p}\varpi_{2i}\Delta InE_{t-i} + \sum_{i=0}^{p}\Psi_{2i}\Delta InTR_{t-i} + \sum_{i=0}^{p}\sigma_{2i}\Delta InK_{t-i} + \sum_{i=0}^{p}\xi_{2i}\Delta InL_{t-i} + \eta_{1c}\, InY_{t-1} + \eta_{2c}\, InCE_{t-1} + \eta_{3c}\, InE_{t-1} + \eta_{4c}\, InTR_{t-1} + \eta_{5c}\, InK_{t-1} + \eta_{6c}\, InL_{t-1} + \mu_{2t} \quad \ldots \tag{2}$$

$$\Delta InE_t = \alpha_3 + \sum_{i=0}^{p}\beta_{3i}\Delta InY_{t-i} + \sum_{i=0}^{p}\kappa_{3i}\Delta InCE_{t-i} + \sum_{i=1}^{p}\varpi_{3i}\Delta InE_{t-i} + \sum_{i=0}^{p}\Psi_{3i}\Delta InTR_{t-i} + \sum_{i=0}^{p}\sigma_{3i}\Delta InK_{t-i} + \sum_{i=1}^{p}\xi_{3i}\Delta InL_{t-i} + \eta_{1v}\, InY_{t-1} + \eta_{2v}\, InCE_{t-1} + \eta_{3v}\, InE_{t-1} + \eta_{4v}\, InTR_{t-1} + \eta_{5v}\, InK_{t-1} + \eta_{6v}\, InL_{t-1} + \mu_{3t} \quad \ldots \tag{3}$$

$$\Delta InTR_t = \alpha_4 + \sum_{i=0}^{p}\beta_{4i}\Delta InY_{t-i} + \sum_{i=0}^{p}\kappa_{4i}\Delta InCE_{t-i} + \sum_{i=0}^{p}\varpi_{4i}\Delta InE_{t-i} + \sum_{i=0}^{p}\Psi_{4i}\Delta InTR_{t-i} + \sum_{i=0}^{p}\sigma_{4i}\Delta InK_{t-i} + \sum_{i=1}^{p}\xi_{4i}\Delta InL_{t-i} + \eta_{1R}\, InY_{t-1} + \eta_{2R}\, InCE_{t-1} + \eta_{3R}\, InE_{t-1} + \eta_{4R}\, InTR_{t-1} + \eta_{5R}\, InK_{t-1} + \eta_{6R}\, InL_{t-1} + \mu_{4t}$$

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$$\Delta InK_t = \alpha_5 + \sum_{i=0}^{p}\beta_{5i}\Delta InY_{t-i} + \sum_{i=0}^{p}\kappa_{5i}\Delta InCE_{t-i} + \sum_{i=0}^{p}\varpi_{5i}\Delta InE_{t-i} + \sum_{i=0}^{p}\Psi_{5i}\Delta InTR_{t-i} + \sum_{i=1}^{p}\sigma_{5i}\Delta InK_{t-i} + \sum_{i=1}^{p}\xi_{5i}\Delta InL_{t-i} + \eta_{1K}\, InY_{t-1} + \eta_{2K}\, InCE_{t-1} + \eta_{3K}\, InE_{t-1} + \eta_{4K}\, InTR_{t-1} + \eta_{5K}\, InK_{t-1} + \eta_{6Y}\, InL_{t-1} + \mu_{5t}$$

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$$\Delta InL_t = \alpha_6 + \sum_{i=0}^{p}\beta_{6i}\Delta InY_{t-i} + \sum_{i=0}^{p}\kappa_{6i}\Delta InCE_{t-i} + \sum_{i=0}^{p}\varpi_{6i}\Delta InE_{t-i} + \sum_{i=0}^{p}\Psi_{6i}\Delta InTR_{t-i} + \sum_{i=0}^{p}\sigma_{6i}\Delta InK_{t-i} + \sum_{i=1}^{p}\xi_{6i}\Delta InL_{t-i} + \eta_{1Z}\, InY_{t-1} + \eta_{2Z}\, InCE_{t-1} + \eta_{3Z}\, InE_{t-1} + \eta_{4Z}\, InTR_{t-1} + \eta_{5Z}\, InK_{t-1} + \eta_{6Z}\, InL_{t-1} + \mu_{6t}$$

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where lnY_t is the log of real GDP, $lnCE_t$ is the log of CO_2 emissions; lnE_t is the log of energy consumption, $InTR_t$ is the log of trade openness, lnK_t is the log of real gross fixed capital formation and lnL_t is the log of total labour force.

In Equation 1, tests for cointegration are carried out by testing the joint significance of the lagged levels of the variables using the F-test where the null of no cointegration is defined by H_O: $d_{1Y}=d_{2Y}=d_{3Y}=d_{4Y}=d_{5Y}=d_{6Y}=0$ against the alternative that H_1: d_{1Y} Í 0, d_{2Y} Í 0, d_{3Y} Í 0, d_{4Y} Í 0, d_{5Y} Í 0, d_{6Y} Í 0. Similarly, in Equation 2, the researchers tested for the joint significance of the lagged levels of the variables using the F-test where the null of no cointegration is defined by H_O: $d_{1C}=d_{2C}=d_{3C}=d_{4C}=d_{5C}=d_{6C}=0$ against the alternative that H_1: d_{1C} Í 0, d_{2C} Í 0, d_{3C} Í 0, d_{4C} Í 0, d_{5C} Í 0, d_{6C} Í 0. Other tests for cointegration using energy, capital and labour. Equations 3, 4, 5 and 6 can also be carried out using similar procedures. The asymptotic distribution of the F-statistic is non-standard under the null and it was originally derived and tabulated by PSS but later modified by Narayan (2005). Two sets of critical values are provided: one, which is appropriate when all the series are I(0) and the other for all the series that are I(1).

According to PSS, in testing for cointegration, if the computed Fstatistic falls above the upper critical bounds, a conclusive inference can be made regarding cointegration without the need to know whether the series were I(0) or I(1). In this case, the null of no cointegration is rejected regardless of whether the series are I(0) or I (1). Alternatively, when the test statistic falls below the lower critical value, the null hypothesis is not rejected regardless of whether the series are I(0) or I(1). In contrast, if the computed test statistic falls inside the lower and the upper bounds, a conclusive inference cannot be made unless we know whether the series were I(0) or I(1). To ascertain the goodness of fit of the ARDL model, the diagnostic test and the stability test are conducted. The diagnostic test examines the serial correlation, functional form, normality and heteroscedisticity associated with the model. The stability test is conducted by employing the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUMsq).

31.3.4 Granger non-causality test

The often used methodologies in the literature for testing causality are the standard Granger non-causality, causality in Johansen and Juselius (1990) ECM, causality in ARDL model proposed by Pesaran and Shin (1998) and causality in the TY multivariate model. The empirical evidence presented in our paper is carried out by using TY because of its advantages over others. The TY procedure is used even when the variables have a different order of integration. In the Johansen model, a pre-requisite is that the variables must be in the same order of integration. Toda and Yamamoto (1995) showed that the pre-tests for cointegration ranks in the Johansen type ECM are very sensitive to the values of nuisance parameters in a finite sample. Hence, causality inference based on Johansen may suffer from severe pre-test biases. If the system contains unit root, standard Wald statistics based on OLS of level vector auto-regressive (VAR) model for testing coefficient restrictions have non-standard asymptotic distribution that may involve nuisance parameters (Sims et al. (1990) and Toda and Phillips [1993]).

The augmented VAR model of TY on the other hand is much appealing because it can be applied for any arbitrary level of integration, $I(0)$, $I(1)$ or $I(2)$ and does not need to be in the same order of integration either. The TY procedure uses a modified Wald test (MWALD) for putting restrictions on the parameters of the VAR (k) from a augmenting VAR ($k + d^{max}$) model, where k is the lag length and d^{max} is the maximum order of integration of variables. The novelty of the TY procedure is there is no loss of information due to differencing because it estimates a VAR in level. The model is valid until k Ó d (Kuzozumi and Yamamoto [2000]).

To undertake the TY version of the Granger non-causality test, we estimate the following system of equations:

$$\begin{bmatrix} InY_t \\ InCE_t \\ InE_t \\ InTR_t \\ InK_t \\ InL_t \end{bmatrix} = A_o + A_1 \begin{bmatrix} InY_{t-1} \\ InCE_{t-1} \\ InE_{t-1} \\ InTR_{t-1} \\ InK_{t-1} \\ InL_{t-1} \end{bmatrix} + A_2 \begin{bmatrix} InY_{t-2} \\ InCE_{t-2} \\ InE_{t-2} \\ InTR_{t-2} \\ InK_{t-2} \\ InL_{t-2} \end{bmatrix} + A_3 \begin{bmatrix} InY_{t-3} \\ InCE_{t-3} \\ InE_{t-3} \\ InTR_{t-3} \\ InK_{t-3} \\ InL_{t-3} \end{bmatrix} + A_4 \begin{bmatrix} InY_{t-4} \\ InCE_{t-4} \\ InE_{t-4} \\ InTR_{t-4} \\ InK_{t-4} \\ InL_{t-4} \end{bmatrix} + A_5 \begin{bmatrix} InY_{t-5} \\ InCE_{t-5} \\ InE_{t-5} \\ InTR_{t-5} \\ InK_{t-5} \\ InL_{t-5} \end{bmatrix} + \begin{bmatrix} \varepsilon InY_t \\ \varepsilon InCE_t \\ \varepsilon InE_t \\ \varepsilon InTR_t \\ \varepsilon InK_t \\ \varepsilon InL_t \end{bmatrix} \quad (7)$$

In Equation 7, A_1é A_5 are six 6×6 matrices of coefficients with Ao being the 6×1 identity matrix, Ůś are the disturbance terms with zero mean and constant variance. From Equation 7, we can test the hypothesis that CO_2 ($lnCE_t$) does not Granger cause economic growth (lnY_t), with the following hypothesis: Ho=$\alpha_{12}^{1} = \alpha_{12}^{2} = \alpha_{12}^{3} = 0$, where $\alpha_{12's}^{i}$ are the coefficients of the CO_2 emission variable in the first equation of the system presented in Equation 7. Additionally, we can test the opposite non-causality from economic growth (lnYt) to CO_2 emissions ($lnCE_t$) in the following hypothesis: Ho =$\alpha_{21}^{1} = \alpha_{21}^{2} = \alpha_{21}^{3}$ =0, where $\alpha_{21's}^{i}$ are the coefficients of the economic growth variable in the second equation of the system presented in Equation 7. Similar tests for testing causality between economic growth, CO_2 emissions, energy consumption, foreign trade, capital and labour can also be carried out using similar procedures.

31.4 Empirical results

Table 31.1 shows the ADF and P.P unit root results for all the variables. The table indicates that all the variables are integrated either in levels or at the first difference, I(0) or I(1). In the presence of I(2) or higher order variables, the computed statistics provided by PSS and Narayan (2005) are not valid (Ang, 2007). This implies that we can confidently apply the PSS-ARDL methodology for testing for cointegration while the TY approach is the most appropriate for testing for causality.

Table 31.1: ADF and Philips- Peron Unit Root Test Results

Variable	ADF test statistic with intercept		P-P test statistic with intercept	
	Level	First Difference	Level	First Difference
Real GDP(InY)	-3.60*	-3.91**	-2.58	-5.7**
Carbon Emission (InCE)	-1.51	-4.85**	-3.91**	-4.8**
Foreign trade (InTR)	-0.24	-3.92**	-0.29	-6.0**
Energy Consumption (InE)	-1.61	-4.51**	-2.30	-8.2**
Capital (InK)	-0.71	-3.69**	-1.24	-3.6*
Labour (InL)	0.16	-4.88**	-1.20	-5.9**

Note: 1. ** (*) indicate 1 %(5%) level of significance.
2. ADF critical values at 1% and 5% are -3.6228 and -2.9446 respectively while P.P critical values at 1% and 5% are -3.6117 and -2.9399 respectively.

31.4.2 Bounds test co-integration result

Having examined the time series characteristics of our data, the next step is where equations 1 ï 6 are estimated to examine the long-run relationships among the variables. As suggested by Pesaran and Shin(1999) and Narayan (2004),since the observations are annual, we choose 2 as the maximum order of lags in the ARDL and estimate for the period of 1970-2009.We also used the Akaike Information Criterion (AIC) to determine the optimal number of lags to be included in the conditional ECM (error correction model). In addition, we tested the reliability of our models by applying a number of diagnostic tests, including tests of autocorrelation, functional form, normality and heteroscedasticity. In general, as can be seen from Table 31.2, we found no evidence of serious violation of all the above tests.

Table 31.2 **.**Diagnostic test for the lag length selected.

Test **Statistics**	**LM Version**	**F Version**
A:Serial Correlation	CHSQ(1)= .40122[.997]	F(1,12)= .45440[.998]
B:Functional Form	CHSQ(1)= .59998[.670]	F(1,12)= .6008[.671]
C:Normality	CHSQ(2)= .69565[.706]	Not applicable
D:Heteroscedasticity	CHSQ(1)= .0028212[.958]	F(1,35)= .0026689[.959]

A:Lagrange multiplier test of residual serial correlation
B:Ramsey's RESET test using the square of the fitted values
C:Based on a test of skewness and kurtosis of residuals
D:Based on the regression of squared residuals on squared fitted values

The results of the cointegration tests are presented in Table 3. Evidence from the table indicates a long-run cointegrating relationship among the series under consideration. The calculated F-statistic of 6.002 denoted by FlnY(Y|lnCE, lnE, InTR,InK,lnL), is higher than the upper bound critical value of 4.43 at 1% for 6 variables (Table C1(iii) Case III: unrestricted intercept and no trend) as tabulated in Pesaran et al (2001). This shows that the null hypothesis of no cointegration among output, CO2 emissions, energy consumption, trade, capital and labour is rejected at the optimal lag length of 2. On the other hand, when the other series (CO2 emissions, energy, trade capital and labour) were used as dependent variables no cointegrating relationship was found.

Table 31.3
F-statistic results of the joint null hypothesis that the coefficients of the levels of the lagged independent variables are zero.

F-Statistic	Lags	
	1	2
F_{lnY}(Y|lnCE, lnE, InTR,InK,lnL)	3.8977**	6.0019***
F_{lnCE}(CE|lnY, lnE, InTR,InK,lnL)	1.6405	2.1442
F_{lnTR}(TR|lnCE,InY,InE,InK,lnL)	3.7326**	1.9663
F_{lnE}(E|lnCE, lnY, InTR,InK,lnL)	1.0062	1.0010
F_{lnK}(K|lnCE, lnE, InTR,InK,lnL)	2.2065	2.546
F_{lnL}(L|lnCE, lnE, InTR,InK,lnL)	2.2281	1.5630

Note: The asymptotic critical value bounds are obtained from Table C1(iii) Case III: unrestricted intercept and no trend for k= 6. Lower bound I(0) = 2.45 and upper bound I(1) =3.61 at 5% significance level, while at the 1% significance level lower bound I(0) = 3.15 and upper bound I(1) = 4.43(See Pesaran *et al*. 2001). The lag structure was selected based on the Akaike Information Criterion. ** denotes the rejection of the null hypothesis at 1% significance level.

Having established the existence of cointegration among the series, we estimated the long-run coefficients. Table 4 shows that all the variables are positively related to output and are statistically significant except the sign of Labour coefficient which is negative and not statistically significant. In other words, higher energy consumption, foreign trade, capital and CO_2 emissions promote economic growth. Specifically, a 1 percent increase in CO_2 leads to 1.1 percent increase in output growth, while a 1 percent increase in capital increases output by only 0 .2 percent. More so, a 1 percent increase in trade increases output by 1.5 percent while the long-run elasticity of output growth with respect to energy consumption is 3 percent indicating that for each 1 percent increase in energy consumption, output growth rise by 3 percent.

Table 31.4. Estimated Long Run Coefficients using the ARDL Approach

ARDL (2,0,0,2,1,1) selected based on AIC
Dependent variable is INY

Regressor	Coefficient	Standard Error	T-Ratio [Prob]
InCE	1.11393	.36071	3.088083[.002]***
InTR	1.53887	.124055	12.4047[.000]***
InE	2.99667	1.3501	2.2196[.024]**
InK	.19567	.04394	4.4530[.000]***
InL	-.4013	.266644	-1.5050[.156]
CONST	-72.2829	14.9779	-4.8260[.000]***

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

The short-run dynamics results are reported in Table 31.5. An examination of the estimated result above shows that the overall fit is satisfactory at the value of R^2 =0.875. This shows that the independent variables used in our model jointly accounted for 87.5 percent of the total variation in output growth. Evidence from the table is reinforced by the long-run estimates presented in table 31.4. The elasticity status of our model shows that while energy consumption in the present period and capital formation in the present period had coefficients of elasticity that are less than one, energy consumption lagged by one year period, foreign trade and carbon emissions had coefficients of elasticity that are greater than one. This shows that economic growth in Nigeria is highly responsive to changes in carbon emissions, energy consumption and foreign trade. It also implies that carbon emissions, energy consumption and foreign trade are some of the major determinants of output growth in Nigeria.

Table 31.5. Error Correction Representation for the parsimonious ARDL Model

ARDL (2,0,0,2,1,1) selected based on AIC.
Dependent variable is dINY

Regressor	Coefficient	Standard Error	T-Ratio[Prob]
dInY(-1)	.30184	.14604	2.0667[.051]**
dInTR	1.23625	.123332	10.0237[.000]***
dInCE	1.00477	.34898	2.87911[.008]***
dInE	.99268	.51975	1.9099[.080]*
dInE(-1)	1.33977	.23221	2.6320[.012]***
dInK	.71426	.17308	4.1268[.000]***
dInL	0.4262	0.3413	1.2486[.231]
dCONST	-62.2433	13.1961	-4.7168[.000]***
ECM(-1)	-.86111	.088756	-9.7020[.000]***

Note: R^2=0.875; Adjusted R^2=0.822; F-stat.(8,29)=22.6697[.000]***; DW-Statistic= 2.4364.
Notes: ***, ** and * denote significant levels at 1%, 5% and 10% respectively

The coefficient of the ECM (-1) as could be observed in Table 31.5 is negative, and highly significant, showing that the model has a self-adjusting mechanism for adjusting the short-run dynamics of the variables with their long run values. This implies that there is a long-run relationship between output growth and its determinants. The speed of adjustment to equilibrium is given by the coefficient of ECM (-1) as -0.86. This speed is very high, indicating that a deviation in output growth from equilibrium is corrected by as high as 86 percent the following year.

31.4.2 **Granger causality test**

In order to ascertain the direction of causality, we estimated the causality tests which are presented in Table 31.6. As we are relatively more interested in the relationship between trade, GDP, CO_2, and energy consumption, we shall concentrate on results pertaining to these variables. The result from the test indicates that international trade granger cause CO_2 in Nigeria without feedback. The positive sign of the sum of lagged coefficients indicates that foreign trade increases carbon emissions implying that foreign trade is harmful to environmental quality in Nigeria. The finding supports the view by Khalim and Inam (2006), Halicioglu (2009) as well as Feridun et al. (2006) who documented that trade openness encourages the inflow of dirty industries which harms the environmental quality in less developed economies like Nigeria where laws and regulations about environment is not strict.

Table 31.6 Granger causality Wald tests.

Null hypothesis	G^2	p-value	Ɇ of lagged coefficients
CO_2 does not cause GDP	5.92	0.051*	CO_2 = 0.040
GDP does not cause CO_2	2.46	0.292	GDP = 0.940
Energy does not cause GDP	7.26	0.013**	Energy = 0.112
GDP does not cause Energy	1.52	0.339	GDP = 0.045
CO_2 does not cause Energy	3.38	0.241	CO_2 = 0.350
Energy does not cause CO_2	6.98	0.030*	Energy = 0.238
Trade does not cause CO_2	9.95	0.001**	Trade = 0.007
CO_2 does not cause Trade	2.42	0.298	CO_2 = -0.880
Capital does not cause GDP	8.36	0.002**	Capital = 0.110
GDP does not cause Capital	0.89	0.641	GDP= -0.025
Labour does not cause GDP	3.71	0.156	Labour=1.470
GDP does not cause Labour	4.44	0.109	GDP = 0.137
Trade does not cause GDP	5.80	0.055*	Trade = 0.150
GDP does not cause Trade	4.12	0.111	GDP = -0.444

Notes: ** and * denote rejection of the null hypothesis of no causality at significant levels of 1% and 5% respectively

Table 31.6 also indicates a unidirectional causality running from energy consumption to CO_2 without feedback implying that an increase in energy consumption leads to an increase in CO_2 emissions. This points to the fact that that energy consumption is the main cause of CO_2 emissions (degradation of the environment). Nigeria is an energy intensive growing economy and a report by World Resources Instituteês Climate Analysis Indicators Tool (CAIT) in 2005 revealed that 54.9 percent of Nigeriaês green house gas (GHG) emissions were produced by activities in the energy sector. This implies that the introduction of low carbon emission technologies and reducing energy consumption especially the consumption of fossil fuels are viable options that can help to reduce carbon dioxide emissions. The energy demand projection for Nigeria indicates that oil consumption will continue to increase in the near future. This will inevitably exacerbate further environmental degradation unless measures are taken to reduce emissions and to find alternative environmental friendly sources of energy. The promotion and utilization of the abundant renewable and clean energy resources in Nigeria such as solar, wind, biomass, ocean waves, and hydropower will drastically reduce emission of CO_2 for a friendly and healthier environment.

Another interesting revelation from the causality test is the existence of unidirectional causality running from carbon dioxide emissions (CO_2) to economic growth without feedback. Consistent with the results from the long-run test presented in Table 31.4, the sum of the lagged coefficients of carbon emissions (CO_2) was positive indicating that higher CO_2 emissions promote economic growth. The implication of our finding is that it is not possible to reduce emissions without sacrificing economic growth as reduction in CO_2 emissions can cause output to decline.

On the causal relationship between energy consumption and economic growth, As can been seen from Table 31.6, the sum of the lagged coefficients of the energy variable is positive implying that more energy consumption promotes economic growth.

31.4.3 **CUSUM and CUSUMSQ test results**

Cumulative sum (CUSUM) and cumulative sum of squares (CUSUMSQ) tests have been employed to investigate the stability of long and short run parameters. Pesaran et al. (1999, 2001) suggested estimating the stability of long and short run estimate through CUSUM and CUSUMSQ tests. Figures 31.3 and 31.4 specify that plots for CUSUM and CUSUMSQ are between the critical boundaries at 5 percent level of significance. This confirms the accuracy of long and short run parameters in the model. Therefore, the preferred output growth model can be used for policy decision-making purposes, such that the impact of policy changes considering the explanatory variables of output growth equation will not cause major distortion in the level of output growth, since the parameters in this equation seem to follow a stable pattern during the estimation period.

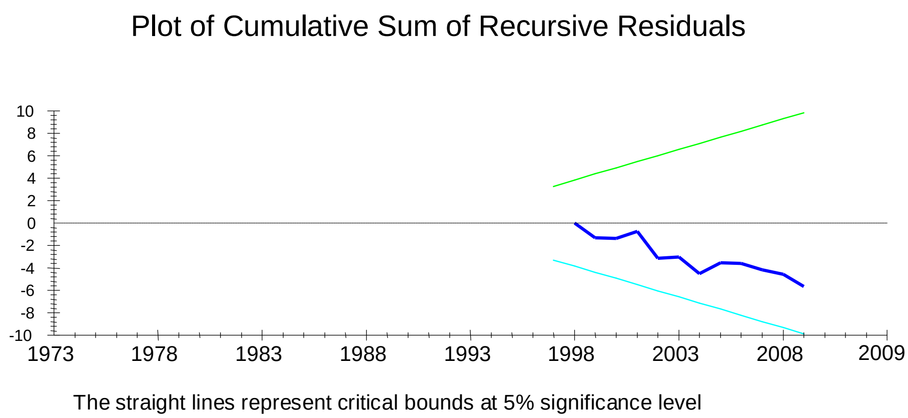

Figure 31.3. Plot of CUSUM

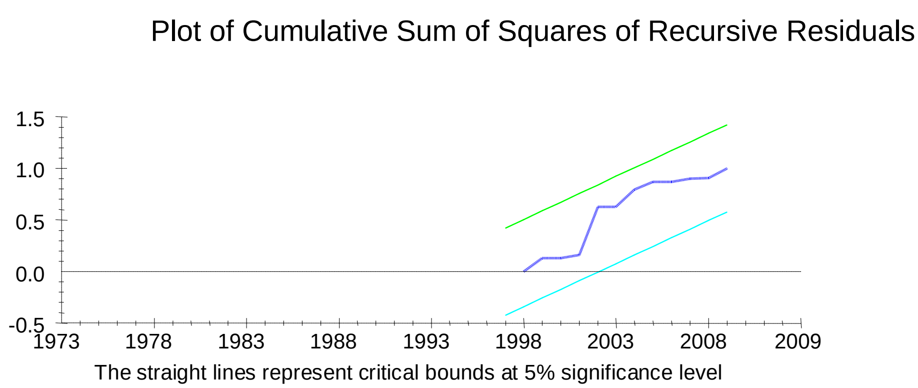

Figure 31.4. Plot of CUSUMSQ

31.5 Conclusion and Policy Implications

Applying the bounds test co-integration procedure and TY causality tests, this paper investigates the dynamic linkages among GDP, energy consumption, foreign trade and carbon emissions for Nigeria during the period 1970ï 2009 in a multivariate model including gross ýxed capital formation and total labour force. The result suggests that there exists robust long-run relationship among the variables. The bounds test result as indicated in the short run and long-run estimates revealed that economic growth in Nigeria is highly responsive to changes in carbon emissions, energy consumption and foreign trade. The results of Granger causality tests indicate unidirectional causal relationship running from CO_2 emissions to output growth; from energy consumption to output growth and also from energy consumption to carbon emissions. Openness to trade increases CO_2 emissions in Nigeria.

These findings have serious implications for policy makers. Effective enforcement of environmental laws and regulation is necessary not only at the federal level but also at other levels of government to curb the menace of environmental degradation occasioned by trade openness. Furthermore, since our results suggest that energy consumption Granger causes carbon emissions, reducing energy consumption, especially the consumption of fossil fuel, seems to be an active way to reduce carbon emissions. In this light, policies diversifying energy source may be applied to reduce the reliance on oil. Nigeria is endowed with abundant sources of renewable energy that can simultaneously address both the energy needs as well as the environmental concerns due to CO_2 emissions. Evidence has shown that these resources are yet to be fully tapped due to lack of funding, infrastructure and political will (ECN, 2008). Nigeria should therefore take active measures to exploit and increase the utilization of these cleaner energy sources (wind, solar, biomass, hydropower, Natural gas).

To combat energy shortages and address the environmental degradation facing the country, improvement in energy efficiency as well as research and investment in clean energy should be an integral part of this process. However, the econometric results upon which the policy suggestions are made should be interpreted with caution bearing in mind the methodological issues related to the study.

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