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Electricity Consumption, Carbon Emissions and Economic Growth in Nigeria

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ABSTRACT: This paper applies a Multivariate Vector Error Correction (VECM) framework to examine the long run and causal relationship between electricity consumption, carbon emissions and economic growth in Nigeria. Using annual time series data for 1970 to 2008, findings show that in the long run, economic growth is associated with increase carbon emissions, while an increase in electricity consumption leads to an increase in carbon emissions. These imply that Nigeria's growth process is pollution intensive, while the negative relationship between electricity consumption (or positive relationship between electricity consumption) and emissions in Nigeria is a clear indication that electricity consumption in the country has intensified carbon emissions. No support was obtained for the hypothesized environmental Kuznets curve (EKC). Granger-causality results confirm a unidirectional causality running from economic growth to carbon emissions, indicating that carbon emissions reduction policies could be pursued without reducing economic growth in Nigeria. No causality was found between electricity and growth, in either way, which further lends credence to the crisis in the Nigerian electricity sector. Overall, the paper submits that efficient planning and increased investment in electricity infrastructure development may be the crucial missing variable in the obtained neutrality hypothesis between electricity and growth.

Keywords: Electricity consumption; Economic growth; Carbon emission; Nigeria
JEL Classifications: Q43; Q49

1. Introduction

Energy-growth-environmental pollution nexus has continued to receive serious attention in the Energy Economics research and literature. Energy is an important factor of production in any economy, even though the value of its share relative to the value of other inputs' share on the output is usually low (3.5%). The efficient exploitation and development of a nation's energy resources is thus of great importance to the progress and well-being of the consuming public and the overall growth of the economy. However, in Nigeria, inadequate development and inefficient management of the energy sector has resulted in a serious demand-supply gap. The supply of electricity, which is one of the most demanded energy sources in the country, has been very erratic giving pressure to high demand for petroleum substitutes. This generation deficit has forced many households and firms operating in the country to rely on self-generated electricity via burning of petroleum fuels. The effect of this trend on global warming and climate change, in terms of addition to carbon dioxide (CO_2) emissions have been enormous. Globally, among several pollutants contributing to climate change, carbon dioxide (CO_2) emissions account for more than 75% of greenhouse gas emissions with about 80% of it generated by the energy sector

Until recently, there have been two parallel literatures on the relationship between economic growth, energy and environmental pollution. The first set of studies (e.g. Akbostanci, *et al*, 2009;

Diao, *et al*, 2009; He and Richard, 2010) have focused on environmental pollutants and economic growth nexus, which are closely related to testing the validity of the so called Environmental Kuznets Curve (EKC) hypothesis, which postulates an inverted U-shaped relationship between per capita income and environmental degradation in the long run.

The second strand (e.g. Mehrara, 2007, Olusegun, 2008, Akinlo, 2009, Esso, 2010) is related to energy consumption and economic growth nexus. A marriage of these two literatures in which the relationship between energy consumption, economic growth and pollution emissions are examined under a multivariate framework has formed a relatively new area of research. Most studies that have focused on this direction for both the developed countries (e.g. Ang, 2007; Apergis and Payne, 2009; Ozturk and Acaravci, 2010, etc) and developing countries (e.g. Jumbe, 2004; Menyah and Wolde-Rufael, 2010) have returned conflicting and mixed results. To the best of our knowledge, evidence of similar studies for Nigeria, are at best scanty. The study by Akinlo (2009), apart from its short span of data set (1980-2006), was based on a bi-variate analysis between electricity consumption and economic growth, rather than on an integrated framework within the energy-growth-emission framework. A likely problem from such study is the loss in power associated with the small sample size and the issue of omitted variable bias.

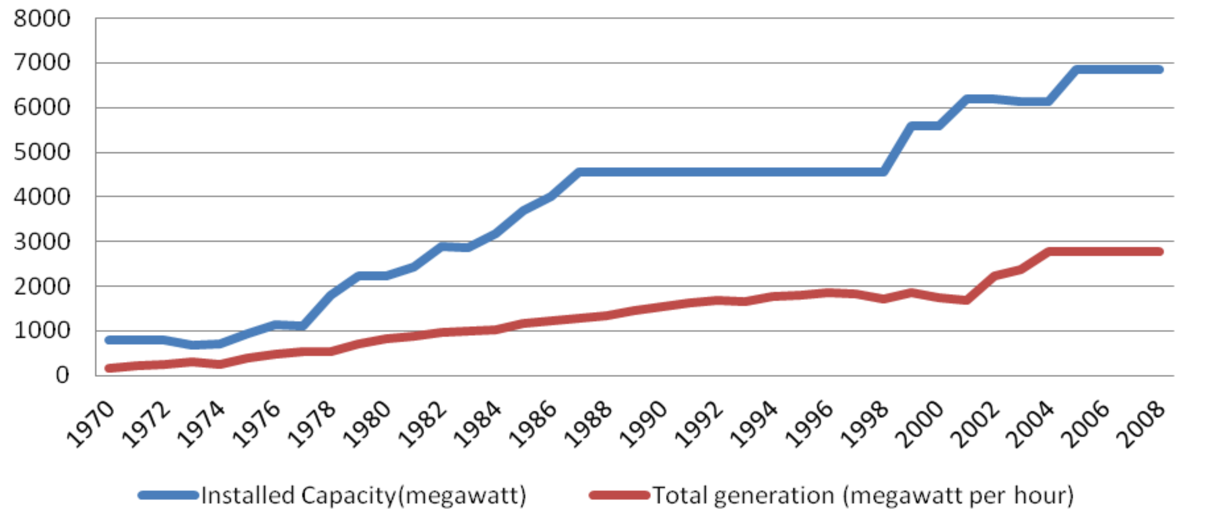
The objective of this paper is to specifically investigate the causal relationship between electricity consumption, carbon emission and output in Nigeria for the period 1970-2008. The direction of causality between electricity, pollution and growth has significant policy implications. For instance, causality running from two-ways or one-way from electricity consumption to output implies that electricity is stimulus to growth and its shortage (which indicates the crisis) will adversely affect growth. However, a unidirectional causality from output to electricity would imply that electricity conservation policies could be pursued without adversely affecting growth. To check the long run properties of the variables employed, we utilized the Auto-regressive Distributed Lag (ARDL) bounds testing approach proposed by Pesaran, *et al.*, (2001) due to its numerous advantages in comparison with other cointegration methods (see Akpan, 2011). Next, we estimate a vector error correction (VECM) based Granger non-causality test. A Variance decomposition analysis is also carried out to check the strength of the Granger causality test beyond the sampled period.

The balance of the paper is the following. Section 2 attempts a brief review of the structure of Nigeria's electricity sector. Section 3 presents a review of previous studies. The methodology and data description is given in section 4 while the results and discussion is done in section 5. Section 6 concludes the paper.

2. An Overview of the Electricity Consumption in Nigeria

Electric power supply is one of the critical infrastructures required for rapid and sustained growth of any nation. It can be termed an indicator of modern development in a country. Hence, the provision of an adequate, affordable, accessible, reliable and sustainable electricity supply is fundamental to the attainment of the broad goals of industrialization, productivity as well as improved quality of life. It is generally recognized that Nigeria is vastly endowed with both renewable energy resources (e.g. solar, hydro, wind, biomass and wood fuel) and non-renewable energy resources (e.g. crude oil, natural gas, lignite and coal). However, in spite of this abundance, the country is still unable to generate enough electricity to meet its domestic demand. Approximately 47% of the population currently has access to electricity (UNDP/WHO, 2009) but experience frequent disruptions to supply and often rely on back-up generators with the attendant environmental consequences. The situation is more acute in the rural area with only 26% having access to electricity, compared to 69% in the urban areas (Ibid). Available statistics as at 2008 shows that the country has about 6862 megawatts (MW) of installed electricity generating capacity, but actual generation is as low as 2779 MW (see Figure 1).

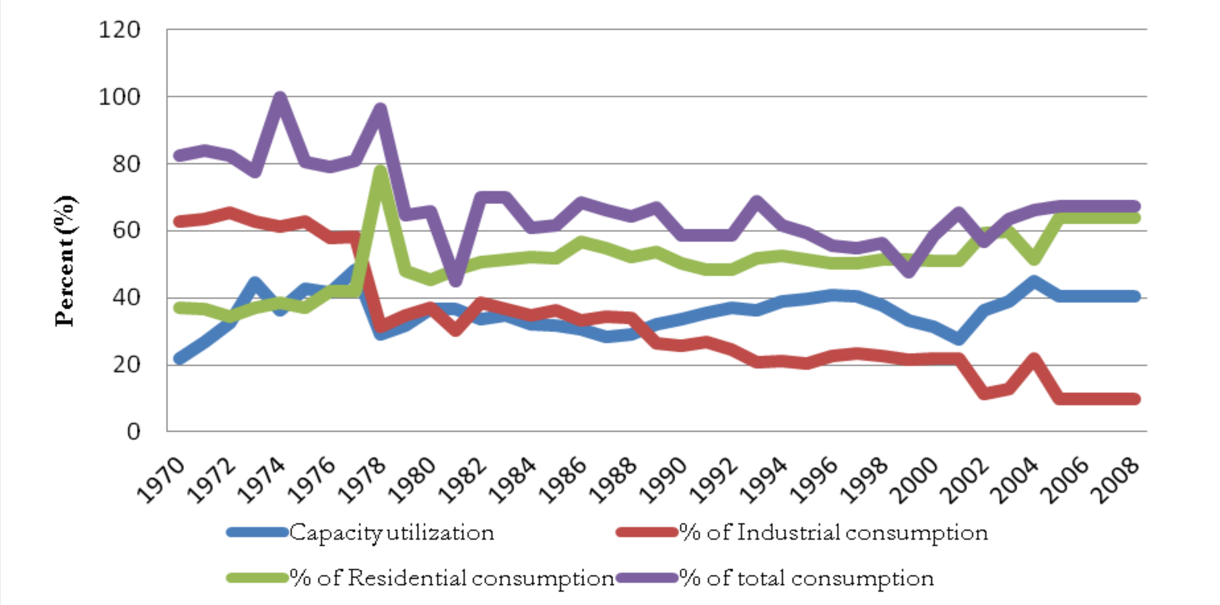
Figure 1: Installed Capacity and Total Generation of Electricity in Nigeria (1970-2008)



Source: Derived from CBN Statistical Bulletin, 2007 & CBN Economic Report for the first half of 2008.

The electricity industry in Nigeria, dominated on the supply side by the Power Holding Company of Nigeria (PHCN), formerly National Electric Power Authority (NEPA), has remained largely inefficient in service delivery, innovation and management. As shown in Figure 2, the proportion of total electricity consumed in the industrial sector has been on a steady decline. Industrial capacity utilization rate fluctuates between 22% and 45% over the period. One striking feature in Figure 2 is the fact that the proportion of total electricity consumed in the industrial sector between 1970 and 1977 was consistently higher than the corresponding share by the residential sector. This trend was however reversed in the latter periods. This is a pointer to the fact that more than 90% of commercial establishments in Nigeria tend to rely more on expensive backup diesel generators that add as much as 25% to total cost of industrial enterprises.

Figure 2: Indicators of Electricity Crisis in Nigeria (1970-2008)



Source: Derived from CBN Statistical Bulletin, 2007 & CBN Economic Report for the first half of 2008.

Factors that contribute to the current electricity crisis in Nigeria have been identified to include generation deficits, weak distribution and transmission infrastructure, poor utility performance, long period of investment and maintenance neglect (Ibitoye and Adenikinju, 2007). In effect, deficient transmission and distribution networks have often result in a large difference between the amount of electricity produced and the amount delivered to end users. In most cases, load shading has to be adopted to avoid system wide blackout. Although, the Nigeria government has spent considerable amount of money in the power sector, the crisis is far from over. Efforts are currently being made to increase power supply in the country to about 10,000 megawatt following the lunching of the Roadmap on the power sector by the present administration. It is yet to be seen how far this objective could be achieved.

3. A Brief Review of Related Studies

The direction of causality between electricity/energy consumption and economic growth could be broadly summarized into four types: *no causality*, the *unidirectional causality* from economic growth to electricity consumption, the *unidirectional causality* running from electricity consumption to economic growth and the *bidirectional causality* between energy consumption and economic growth. It should be noted that each one of these possibilities has important policy implications for energy policy. For instance, the *no causality,* which is also referred to as the *neutrality hypothesis,* implies that electricity consumption is not correlated with economic growth. This further implies that neither conservative nor expansive policies in relation to electricity consumption have any effect on economic growth. The finding of a *unidirectional causality* running from economic growth to electricity consumption, which is also referred to as the *conservation hypothesis,* implies that energy conservation policies could be pursued with little or no adverse effect on economic growth. On the other hand, a *unidirectional causality* from electricity consumption to economic growth, also called *the growth hypothesis,* indicates that any restrictions (increase) on energy usage may adversely (positively) affect economic growth. Lastly, bidirectional *causality* or the *feedback hypothesis* implies that both energy consumption and economic growth are jointly determined and affected at the same time (Jumbe, 2004; Apergis and Payne, 2009; Ozturk, 2010).

A large part of the literature has been devoted to testing the nexus between carbon emissions and income growth. These studies are closely related to testing the validity of the environmental Kuznets curve (EKC). Proponents of the EKC hypothesis have argued that the level of environmental degradation and economic growth follows an inverted U-shaped relationship. Studies on this topical issue have blossom after Grossman and Krueger (1995) and Selden and Song (1995) provided the empirical evidence that the economic growth will lead to a gradual degradation of environment in its initial stages and then, after a certain level of growth, leads to an improvement in the environmental conditions[1] However, empirical evidence on the existence of the EKC hypothesis is at best mixed (see Akpan and Chuku, 2011).

On one hand, a quick view of the literature shows that a number of studies that have examined the energy-economic growth nexus have returned mixed and sometimes conflicting results[2]. Some studies have identified causality running from electricity/energy consumption to economic growth for a broad sample of countries. These include Chang, *et al* (2001) for Taiwan, Wolde-Rufael (2004) for Shangai, Altinay and Karagol (2005) for Turkey, Shiu and Lam (2004) for China, and Akinlo (2009) for Nigeria. On the other hand, the presence of unidirectional causality from real economic activity to electricity consumption have been found by others including Jamil and Ahmad (2010) for Pakistan, Halicioglu (2007) for Turkey, Narayan and Smyth (2005) for Australia, and Yoo and Kim (2006) for Indonesia, and Adebola (2011) for Bostwana. Yet some other studies have found bidirectional causality between electricity consumption and economic growth. Studies in these moulds include Yang (2000) for Taiwan, Jumbe (2004) for Malawi, Yoo (2005) for Korea, Tang (2008) for Malaysia

[1] Ekins (1997), Dinda (2004) and Stern (2004), among others, provide a comprehensive and critical survey of studies that that tested the EKC hypothesis.

[2] An excellent review and a chronological list of the empirical literature on the causality between energy/electricity consumption and economic growth (by author, time-frame, country, methodology and results) for both country-specific studies and multi-country studies can been found in Ozturk (2010). See also Payne (2010), Apergis and Payne (2011) and Jamil and Ahmad (2010).

and Odhiambo (2009) for South Africa and Sami (2011) for Japan. There are also studies (e.g. Halicioglu, 2009; Payne, 2009) that have reported a no causality between electricity/energy consumption and economic growth. The conflicting results mentioned above have been attributed, among other things, to the different data set and time period, alternative econometric methodologies and different countries' peculiarities (Ozturk, 2010). This implies that the literature on income-environment-energy nexus is still far from being conclusive to provide policy recommendation that can be applied across countries. A quick insight to this indicates that only a country specific study can provide a useful policy direction. This study contributes to this growing body of research in the Nigerian context.

4. **Methodology and Data**

4.1 The Model and Data

Following the approach adopted by Ang (2007), Acaravci and Ozturk (2010), and Lean and Smyth (2010), the long-run relationship between electricity consumption, carbon emissions and economic growth in Nigeria can be specified as follows:

$$c_t = \beta_0 + \beta_1 ec_t + \beta_2 y_t + \beta_3 {y_t}^2 + \varepsilon_t \qquad (1)$$

Where *c is* carbon dioxide emissions (in millions metric tons), *ec is* an index of electricity consumption measured in megawatts per hours, *y* is real income per capita (measured in 2005 constant U.S. \$), y^2 is the square of real income and ε is the error term. β_1, β_2 and β_3 correspond to the long run parameters of electricity consumption, real income and the square of real of real income, respectively. The expected sign of β_1 is positive, under normal conditions. But in the Nigerian economy where erratic power supply has lasted for over three decades now, forcing economic agent to private power generation as alternative sources of power, β_1 may well be negative given that a decrease in electricity consumption (capturing the effect of electricity crisis) should results in an increase in carbon emissions due to increase petroleum utilization in own-generation of electricity by economic agents. Under the EKC hypothesis, the signs of β_2 and β_3 are expected to be positive and negative respectively, in order to reflect the inverted U-shape pattern. The turning point occurs at an income level of $\frac{\beta_2}{2\beta_3}$. The statistical insignificance of β_3 suggests a monotonic increase in the relationship between carbon emission and real income.

However, to avoid overestimating the importance of the independent variables and multicollinearity problem, we follow the procedure of Pao, Yu and Yang (2011) by using the nested linear models with their variance inflation factor (VIF) and adjusted *R*-squared to evaluate how well the variables *ec, y,* and y^2 work together to accurately explain the carbon emission variable, *c*. Usually, the VIF measures the impact of multicollinearity among the explanatory variables in a regression model on the precision of estimation. It expresses the degree to which multicollinearity amongst the explanatory variables degrades the precision of an estimate. VIF is measured as:

$$VIF(\beta_j) = 1/(1 - R(j)^2 \qquad (2)$$

Where $R(j)$ is the multiple correlation coefficient between variable *j* and the other independent variables. The general rule is that the VIF should not exceed 10 (see Belsley, Kuh and Welsch, 1980; Robinson and Schumacker, 2009). Values greater than 10 may indicate a collinearity problem. For the present purpose, we re-specify the following:

$$c_t = \alpha_1 + \delta_1 ec_t + \varepsilon_t \qquad (3a)$$
$$c_t = \alpha_2 + \delta_2 y_t + \varepsilon_t \qquad (3b)$$
$$c_t = \alpha_3 + \delta_3 y_t + \gamma_3 {y_t}^2 + \varepsilon_t \qquad (3c)$$
$$c_t = \alpha_4 + \varphi_4 ec_t + \delta_4 y_t + \gamma_4 {y_t}^2 + \varepsilon_t \qquad (3d)$$
$$c_t = \alpha_5 + \varphi_5 ec_t + \delta_5 y_t + \varepsilon_t \qquad (3e)$$

If adding ${y_t}^2$ provides an evidence of multicollinearity through the VIF, we might conclude that including ${y_t}^2$ is not desirable. It follows that if ${y_t}^2$ is excluded the relationship between carbon emission and real income is monotonic. In this case, the EKC hypothesis becomes invalid.

The data employed are annual ones spanning the period 1970-2008. The data on electricity crises was obtained from Central Bank of Nigeria's Statistical Bulletin, 2009. The variable is measured in

Megawatt per hour. Carbon emissions for the study period, measured in metric tons per capita, were extracted from the World Development Indicators, *CD-ROM* while real income per capita (measured in 2005 constant US $) was taken from the Penn World Table version 6.3 developed by Alan, *et al* (2009).

4.2 Econometric Procedure

To check the long-run relationships among the included variables, we employed the Autoregressive Distributed Lag (ARDL) bounds test approach to cointegration proposed by Pesaran and Shin (1999) and extended by Pesaran, et al. (2001). The statistics underlying this test is the Wald or *F*-statistic in a generalized Dickey-Fuller type regression, which is used to test the significance of lagged levels of the variables under consideration in a conditional unrestricted equilibrium correction model (UECM). The ARDL approach is reputed to posses several advantages over other traditional approaches. First is its flexibility: it can be applied irrespective of whether the underlying regressors are purely I (0), *I* (I), or mutually cointegrated (Akpan, 2011). Thus, because the bounds test does not depend on pretesting the order of integration of the variables, it eliminates the uncertainty associated with pretesting the order of cointegration (Narayan and Narayan, 2004). In essence, the approach does not require all the variables in the system to be of equal order of integration[3]. Also the approach can be applied to studies that employ relatively small sample size, such as the present study. As demonstrated by Pesaran and Shin (1999), the small sample properties of the ARDL approach are far superior to that of the Johansen and Juselius'(1990) cointegration technique[4]. Another important advantage of this procedure is that the estimation is possible even when some of the explanatory variables are endogenous. The implementation of the bounds test is straightforward. Assume a vector of two variables, z_t , where $z_t = (y_t, x_t')'$, y_t is the dependent variable and x_t is a vector of regressors. The data generating process of z_t is a *P*-order vector autoregression. For cointegration analysis, it is crucial that Δy_t be modeled as a conditional error correction model of the form:

$$\Delta y_t = \beta_0 + \pi_{yy} y_{t-1} + \pi_{yx} x_{t-1} + \sum_{i=1}^{p} \vartheta_i \, \Delta y_{t-i} + \sum_{j=0}^{q} \varphi_j{}' \, \Delta x_{t-j} + \mu_t \qquad (4)$$

Where π_{yy} and π_{yx} are long–run multipliers. β_0 is the drift parameter while u_t is the error term. Lagged values of Δy_t and current and lagged values of Δx_t are used to model the short-run dynamic structure of the variables. The bounds testing procedure for the absence of any level relationship between y_t and x_t is through the exclusion of the lagged-level variables y_{t-1} and x_{t-1} in equation (4). In other words, our test for the absence of a conditional level relationship between y_t and x_t entails the following null and alternative hypotheses:

$$H_0: \pi_{yy} = 0, \pi_{yx} = 0, \qquad (5)$$
$$H_1: \pi_{yy} \neq 0, \pi_{yx} \neq 0, or \;\; \pi_{yy} = 0, \pi_{yx} \neq 0 \; or \;\; \pi_{yy} \neq 0, \pi_{yx} = 0 \qquad (6)$$

The computed *F*-statistic is then compared with two sets of critical values provided by Pesaran, *et al.* (2001). One set assumes that all variables are *I*(0) and the other assumes they are *I*(1). If the computed *F*-statistic exceeds the upper critical value, then the null hypothesis of no cointegration will be rejected. If it is below the lower bound, then the null hypothesis of no cointegration cannot be rejected. However, if it falls into the bounds, the test remains inconclusive. Recently, Narayan (2005) has argued that the critical bounds provided by Pesaran, *et al.* (2001) are inappropriate in small sample size[5] and has regenerates new sets of critical values for samples ranging from 30 to 80 observations. To this end, given the relatively small sample size in this study (39 observations), appropriate critical values will be extracted from the latter source.

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[3] The major drawback of the ARDL approach is that it fails to provide robust results if the order of integration is greater than one , e.g. *I*(2).

[4] The Johansen and Juselius's Maximum Likelihood technique is based on a VAR systems of equations which is fairly data intensive and there is substantial loss of degree of freedom, which could render the validity of most of the results based on relatively small sample dubious. These limitations do not apply to the ARDL methodology (see. Romill and Song., 2001)

[5] The critical values reported in Pesaran and Shin (1999) and Pesaran, *et al* (2001) are based on sample sizes of 500 and 1000 observations respectively.

Next, since the robustness of the bounds test technique is questionable if the unit root properties of the examined variables is *I*(2) or beyond, a battery of unit root test statistics are employed. These include the traditional Augmented Dickey Fuller (ADF) test, the Phillips-Perron(PP) test as well as the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test. While the former test statistics are designed on the basis of the null hypothesis that the series is *I*(1) , the KPSS tests statistic assumes that the series are (trend) stationary under the null, while the alternative is that the series is *I*(1). The KPSS statistic is based on the residuals from the OLS regression of y_t on the exogenous variables x_t :

$$y_t = x_t'\varphi + e_t \qquad (7)$$

The test statistic itself is defined as:

$$\eta = \sum_{t=1}^{T} S^2{}_t \Big/ T^2 \bar{\sigma}^2 \qquad (8)$$

Where $S_t = \sum_{s=1}^{t} e_s$ is a cumulative residual function and $\bar{\sigma}^2$ is an estimate of the long-run variance of $e_t = (y_t - \bar{y})$. Under the null, this statistic has a well-defined (nonstandard) asymptotic distribution, which is free of nuisance parameters and has been tabulated by simulation. Under the alternative, the statistic diverges. As a consequence, it is possible to construct a one-sided test based on η , where the null is rejected if η is bigger than the appropriate critical value. Hence, the KPSS test is used to complement the ADF and PP tests in order to obtain robust results.

4.3 Granger Causality Analysis

It should be noted that co-integration implies the existence of causality, at least in one direction. However, it does not indicate the direction of the causal relationship. Hence, to shed light on the direction of causality, and if the variables are cointegrated, we estimate an error-correction based Granger causality models. In contrast to the conventional Granger causality method, this approach allows for the inclusion of the lagged error-correction term (ECT) derived from the cointegration equation. Consequently, the following vector error correction models (VECM) may be specified to explore the causal relationships between the variables:

$$\Delta c_t = \alpha_1 + \sum_{i=1}^{l} \partial_{1i}\,\Delta c_{t-i} + \sum_{i=1}^{m} \omega_{1i}\,\Delta ec_{t-i} + \sum_{i=1}^{n} \varphi_{1i}\,\Delta y_{t-i} + \sum_{i=1}^{p} \gamma_{1i}\,\Delta y^2{}_{t-i} + \pi_1 ect_{t-1} + \mu_{1t} \qquad (9a)$$

$$\Delta ec_t = \alpha_2 + \sum_{i=1}^{l} \partial_{2i}\,\Delta c_{t-i} + \sum_{i=1}^{m} \omega_{2i}\,\Delta ec_{t-i} + \sum_{i=1}^{n} \varphi_{2i}\,\Delta y_{t-i} + \sum_{i=1}^{p} \gamma_{2i}\,\Delta y^2{}_{t-i} + \pi_2 ect_{t-1} + \mu_{2t} \qquad (9b)$$

$$\Delta y_t = \alpha_3 + \sum_{i=1}^{l} \partial_{3i}\,\Delta c_{t-i} + \sum_{i=1}^{m} \omega_{3i}\,\Delta ec_{t-i} + \sum_{i=1}^{n} \varphi_{3i}\,\Delta y_{t-i} + \sum_{i=1}^{p} \gamma_{3i}\,\Delta y^2{}_{t-i} + \pi_3 ect_{t-1} + \mu_{3t} \qquad (9c)$$

$$\Delta y^2{}_t = \alpha_4 + \sum_{i=1}^{l} \partial_{4i}\,\Delta c_{t-i} + \sum_{i=1}^{m} \omega_{4i}\,\Delta ec_{t-i} + \sum_{i=1}^{n} \varphi_{4i}\,\Delta y_{t-i} + \sum_{i=1}^{p} \gamma_{4i}\,\Delta y^2{}_{t-i} + \pi_4 ect_{t-1} + \mu_{4t} \qquad (9d)$$

Where *ect*, explicitly defined as

$$\widehat{ect}_{t-1} = c_{t-1} - \hat{\beta}_0 - \hat{\beta}_1 ec_{t-1} - \hat{\beta}_2 y_{t-1} - \hat{\beta}_3 y^2{}_{t-1} \qquad \dots\dots\dots\dots (10)$$

is the one period lagged error-correction term derived from the long term co-integration relationship described in equation (1).The sign Δ is the first-difference operator; the optimum lag lengths *l, m, n* and *p* are selected based on the Schwarz-Bayesian information criteria (SBC); μ_{it} are the independently and normally distributed error terms with zero mean and constant variance. Using equations (9a-d), two different causality tests could be performed:

i. Short-run or weak Granger causalities are examined through the significance of the relevant lagged dynamic terms using the *F*-statistic or the Wald test, which follows the chi-square (χ^2) distribution. For instance using equation (7a), to detect whether Δy_t and $\Delta y^2{}_t$ do not Granger cause Δc_t in the short-run, we test the null hypothesis: H_0: all $\varphi_{1i} =$ all γ_{1i} = 0. Rejecting this implies that real income (economic growth) Granger cause emission growth in the short-run[6]. However, in testing whether carbon emission or electricity consumption (as in equations 9c-d) Granger cause real income, a different approach is required since there are two variables that capture real income in the specification. Hence, following Ang (2007) and using equations (9c-d), we can estimate an unrestricted VECM by imposing the restrictions: all $\partial_{3i} =$ all ∂_{4i} = 0 (in the case of carbon emissions) and the restrictions: all ω_{3i} = all ω_{4i} = 0 (in the case of electricity consumption). Similar to the conventional *F*-test, a likelihood ratio test can be performed on the determinants of residual variance of these two models[7].

ii. Long-run Granger causalities (or tests for weak exogeneity) are examined through the significance of the lagged *ect* coefficients, using the *t*-test. For instance, this requires testing the null: H_0: π_1 = 0 for non-causality from long-run equilibrium deviation to carbon emissions in equation (9a). For reasons earlier advanced, the non-causality from long-run equilibrium deviation to real income and its square (Δy_t and $\Delta y^2{}_t$) requires non-rejection of the hypothesis: H_0 : $\pi_3 = \pi_4 = 0$. This later hypothesis testing is through the likelihood ratio test which follows a χ^2 distribution.

4.4 Variance Decomposition Analysis

The Granger causality test only indicates causality within the sampled period without allowing us to gauge its relative strength among the series beyond the sampled period. To examine this, we applied the generalized forecast error variance decompositions, which measure the percentage of a variable's forecast error variance that occurs as a result of a shock from a variable from the system. As noted by Sims (1980), if a variable is truly exogenous with respect to the other variables in the system, own innovations will explain all of the variable's forecast error variance. If own innovations are explaining a variable's entire forecast error then that variable may be described as truly exogenous with respect to other variables in the system. Usually, the results are sensitive to the manner in which the variables are ordered. The common practice is to propose the most plausible ordering based on economic theory and to verify the robustness of the results by reversing the ordering. However, following Jamil and Ahmad (2010), we do not pre-suppose any order based on theoretical underpinnings, but applied all six possible orderings and then take the average.

5. Empirical Results and Discussion

The results of the unit root properties of the examined variables are displayed in Table 1 below. Both the ADF and the KPSS tests are consistent that all the variables are *1*(1) at the 1% level of significance. The same is true using the PP statistic, except that real income and its square are shown to be stationary at levels. In sum, all the three test statistics confirmed that none of the variables is *1*(2) or beyond – a necessary condition for the application of the bounds test.

Table 1. Summary of Unit Root Test Results

Variable	ADF		PP		KPSS	
	Level	Ist Diff.	Level	Ist Diff.	Level	Ist Diff.
c	-2.33(0)	-6.38(0)***	-2.35(1)	-6.44(6)***	0.22(4)***	0.15(4)***
ec	-2.21(1)	8.51(0)***	-2.48(3)	-8.56(1)***	0.73(5)***	0.27(1)***
y	-2.28(0)*	- 5.68(0)***	-5.36(37)***	-5.70(6)***	0.67(5)***	0.39(5)***
y^2	-2.28(0)*	-5.68(0)***	-5.36(37)***	-5.70(6)***	0.67(5)***	0.39(5)***

Note*: ***, **,* denotes significance at the 1%, 5%, and 10% levels respectively. The values in bracket ( ) for the ADF test indicate the optimal lag selected by the SIC within a maximum lag of 9. For the PP and KPSS tests,*

[6] Granger causality has little to do with the everyday usage of the word "causality". The claim that a variable has no predictive content corresponds to the null hypothesis that the coefficients on all lags of that variable are zero.
[7] However, if the square of real income is eventually excluded from the specification, the null hypothesis can simply be tested by applying the Wald test.

the spectral estimation is based on the Bartlett Kernel Method and the values in bracket ( ) indicate the bandwidth selection using the Newey-West approach. All estimations assume a constant term.

The bounds *F*-test for cointegration relations among the variables are presented in Table 2. The test, which normalized on carbon emission, electricity consumption and real income, returns evidence of long-run relationship among the variables, but remains inconclusive when the square of real income was used as the dependent variable. This finding is a further indication of the need to evaluate its inclusion in the estimation.

Table 2. Bounds Test Result for Cointegration Relations

Dependent Variable	SIC Lag		Calculated *F*-statistic		Prob.		Outcome
$F_c\left(c/ec, y, y^2\right)$	2		8.633***		0.07		Cointegration
$F_{ec}\left(ec/c, y, y^2\right)$	2		8.181***		0.00		Cointegration
$F_y\left(y/c, ec, y^2\right)$	2		10.741***		4.6e-005		Cointegration
$F_{y^2}\left(y^2/c, ec, y\right)$	2		3.705		0.019		Inconclusive
Critical Values	**1%**		**5%**		**10%**		
	I(0)	*I*(1)	*I*(0)	*I*(1)	*I*(0)	*I*(1)	
K= 4	4.428	6.250	3.202	4.544	2.660	3.838	

Note*: K is the number of regressors, Critical values were extracted from Narayan (2005) Case III: Unrestricted intercept and no trend,. ***, **, * denotes statistical significance at 1%, 5%, and 10% levels respectively*.

Before estimating the vector error correction models outlined in equation (9), we estimate equation 3 to investigate if there is any serious multicollinearity problem by including the square of real income in the specification. The estimated coefficients and the respective variance inflation factor (VIFs) are shown in Table 3. The results show that including the square of real income generates serious multicollinearity problem and therefore including it is not desirable. This is confirmed by the large values of VIF for the income variables in equations (3c-d). In addition, the non-linearity tests on equation (3d) do not confirm that the specification is non-linear. The RESET test further indicates that the specification in equation (3d) is not adequate. Overall, the results show that equation (3e) is more appropriate. Hence, our results do not support the EKC hypothesized U-shaped relationship between emission and real income per capita. Rather, it indicates a positive and monotonic relationship. This implies that increase in real income per capita comes with an increase in environmental pollution in Nigeria.

This has a lot of implications for the Nigerian development generally. It means that the disregards or lack of governmental commitment to the generation and supply of electricity has already generated serious deleterious effects on the environment. Today in Nigeria, due to unreliable electricity supply, every industrial plant has its carbonated-fuel-burning electricity generating plant, each burning more fuel than its electricity need, each generating more green-house gases and adversely affecting the environment than would have been if the public sector power supply was efficient or even effective. The same story goes for the household income growth, energy consumption and impact on carbon emission. Another issue of deep concern is the fact the Nigerian manufacturing, nay the industrial, sector is a rapidly growing one, new production plants are springing up and the trend will continue, with high need for electricity. Where the public sector cannot supply, the sector operators will naturally plant a petroleum-using electricity generating sets. This will sustain this observed adverse trend of output expansion and an increasing carbon emission in Nigeria confirmed in the results of this study.

That the Nigerian EKC is on the rising segment is also an expected result in our energy consumption and carbon emission relations. Simply, Nigerian growth is not associated with increase technological capacity which would have resulted in energy conservation and minimization of carbon emission, or would have resulted in the use of cleaner, non-carbonated energy sources. On the contrary growth in the national output from 1980s till date has been trailed by falling trend in hydro-electricity sources and public supplies electricity generally. The repercussion of this has been that economic growth is followed by, or generates, an increase in carbon emission due to private generation of electricity using carbonated fuel sources.

Table 3. Estimated Coefficients for Equation 3

Independent Variables	(3a)	(3b)	(3c)	(3d)	(3e)
Constant	0.7379 (4.8e-013)***	0.2121 (0.1174)	-0.9063 (0.1093)	-0.4655 (0.4720)	0.2443 (0.0618)*
ec	-5.613e-05 (0.4077)	-	-	-8.79e-05 (0.1948) [1.472]	-0.0001 (0.0341)** [1.087]
y	-	0.0003 (0.0007)***	0.0016 (0.0157)** [67.371]	0.0012 (0.1166) [87.691]	0.0004 (0.0001)*** [1.087]
y^2	-	-	-3.83e-07 (0.0445)** [67.371]	-2.39e-07 (0.2657) [91.691]	-
R-squared *Adj. R-squared* *F-value* *DW* *RESET* *Non-Linearity*	0.0186 -0.0079	0.2687 0.2489	0.3472 0.3110 9.577 (0.000) 0.741	0.3783 0.3250 7.099 (0.001) 0.156 (0.856) 5.823 (0.121)	0.3556 0.3198 9.932 (0.000) 0.676 2.306 (0.115) 6.959 (0.031)

Note: ***, **,* indicate significant at the 1%, 5% and 10% levels respectively. Values in ( ) are the P-values while those in [ ] are the variance inflation factors.

The electricity consumption (the proxy for electricity crisis in this study) and carbon emission rightly has negatively signed coefficient. As expected the poorly supplied public sector electricity has naturally led to firms generating their own power and using the public power supply as a standby. It is only very poor households that do not own electricity-generating set. The effect of this is that as electricity consumption deepens (that is, as publicly-supplied electricity shortages increase or as its consumption, by default, falls), the private sector and households go into the survivalist strategy of self-generation of electricity. The outcome of this own-electricity generation strategy has negatively affected environment in terms of increase in emission of carbon-gases. Government in Nigeria should observe that public sector supply of reliable electricity is environmental safeguarding policy; otherwise, the way the country is going is not just the problem of massive substitution of petroleum fuels for electricity, but of high generation of carbon-gases to the environment, which is dangerous to the present generation and a threat to the future. The entire results should, however, be interpreted with caution, as the presence of first order autocorrelation cannot be ruled out (see the DW statistic). Moreover, the model may still suffer from specification bias judged by the *RESET* test.

Table 4 presents the causality test results that are central to this study. The result shows that there is a short-run unidirectional causality from real income per capita to carbon emissions in Nigeria. This implies that short-run industrial production in the country have a significant impact on Nigeria's environmental quality. This suggests that to improve the country's environmental quality, government should ensure the supply of reliable electricity so that the industrial sector and the households may use publicly supplied electricity, which is non-carbon emitting.

Results from Table 4 further show that in the long-run, electricity consumption and real income per capita Granger-cause carbon emissions in Nigeria. This follows the statistical significance of the error-correction term when carbon emissions is used as the dependent variable. Moreover, real income and electricity consumption appear to be weakly exogenous. There is no causal evidence from either carbon emissions or real income to electricity crisis in both the short-run and in the long run. Also, neither carbon emissions nor electricity consumption Granger-cause real income per capita in both the short-run and in the long run. This result tends to support the *neutrality hypothesis*, which implies that, neither conservative nor expansive policies in relation to electricity consumption in Nigeria have any effect on economic growth. This may be because poor quality of publicly supplied electricity has over the years caused investors not to depend on it for their production plans. It does mean that if the quality of electricity is not improved, investment and growth will not depend on it. The trend in the relationship depends on the quality of electricity publicly supplied, on the strength of substitutability between electricity and petroleum fuels, and on the energy-quality threshold for such substitution.

Table 4. Results of Causality Tests

Dep. Variable	*Source of causation (independent variables)*			
	Short-run (Wald χ^2 statistic)			*Long-run (t-statistics)*
	Δc_t	Δec_t	Δy_t	*ECT*
Δc_t	-	0.055 (0.815)	4.037 (0.045)**	3.119 (0.004)***
Δec_t	1.429 (0.232)	-	0.381 (0.232)	-0.822 (0.417)
Δy_t	0.358 (0.549)	0.880 (0.348)	-	-0.006 (0.996)

Note: Figures in bracket are the P-values, ***,**,* indicate statistical significance at the 1%,5% and 10% levels respectively.

Presented in Table 5 are the results of the variance decomposition analysis. The results enable us to deduce the percentage of a variable's forecast error variance that arises from a shock from a variable in the system. It is clear from the table that between 86-60 % of forecast error variance in carbon emissions are explained predominantly by its own innovations in the first 6 years. However, beyond the 7th year, real income per capita accounts for most of the innovations in carbon emissions per capita. The initial impact of real income on forecast error variance of carbon emission, which is around 14% in the 1st year accounts for about 56% in the 10th year. These findings provide strong support to the Granger-causality results. Very little of the innovations can be attributed to a shock in electricity consumption. Turning attention to a shock in real income per capita, we found that although innovations in carbon emissions explains about 14-22% of the forecast error variance, most of the innovations are accounted for by its own shock throughout the period. Overall, the influence of electricity consumption on real income per capita is unambiguously negligible. Almost similar results are obtained for the shock in electricity consumption which are chiefly explained by own innovations. This implies that electricity consumption is relatively exogenous in the system.

Table 5. Variance Decomposition Results

Decomposition of variance for CO_2 emissions (*c*)				
Period	Std. Error	*ec*	*y*	*c*
1	0.123	0.69	14.36	84.95
2	0.137	0.75	13.44	85.81
3	0.147	0.86	15.82	83.32
4	0.159	1.73	21.41	76.86
5	0.173	3.08	28.33	68.59
6	0.189	4.47	34.76	60.76
7	0.205	5.67	40.07	42.57
8	0.220	6.63	44.25	38.33
9	0.235	7.40	47.55	45.05
10	0.249	6.87	55.74	41.82

Decomposition of variance for real income per capita (*y*)				
Period	Std. Error	*ec*	*y*	*c*
1	120.621	0.07	85.50	14.43
2	202.097	0.40	82.93	16.67
3	261.668	0.48	81.74	17.78
4	309.422	0.47	80.74	18.80
5	349.544	0.43	79.91	19.65
6	384.661	0.40	79.25	20.35
7	416.320	0.37	78.72	20.91
8	445.458	0.35	78.29	21.35
9	472.663	0.33	77.95	21.72
10	498.316	0.32	77.67	22.01
Decomposition of variance for electricity consumption (*ec*)				
Period	Std. Error	*ec*	*y*	*c*
1	100.545	99.16	0.08	0.76
2	147.611	91.16	1.48	6.53
3	183.258	90.99	1.39	7.63
4	213.795	90.45	1.30	8.25
5	240.795	90.16	1.22	8.62
6	265.205	89.97	1.17	8.86
7	287.614	89.85	1.13	9.03
8	308.425	89.75	1.10	9.15
9	327.928	89.68	1.08	9.24
10	346.338	89.63	1.06	9.32

5. Conclusion and Policy Implications

This paper investigates the long-run and causal relationship between electricity consumption (which captures the effect, and thus adopted as a proxy, of electricity crisis), carbon emissions and economic growth in Nigeria over the period 1970-2008. The autoregressive distributed lag (ARDL) bounds test was applied to examine the long-run co-integrating properties of the variables. In addition, the short and long run causality relationships between the variables were examined using a multivariate vector error-correction model (VECM) while the variance decomposition analysis was conducted to check the strength of the causality beyond the sampled period.

The empirical analysis returns evidence of long-run relationship among the variables. The EKC hypothesis was not validated by our results. In the long run, real income was found to be associated with increase in carbon emission in the Nigerian case, while electricity consumption and emissions are negatively related. This negative relationship, which is contrary to theoretical expectation, could be a reflection of the large deficit in the supply and surplus demand of electricity in Nigeria. To fulfill increased electricity supply in the country, efficient planning and investment in electricity infrastructure development is crucial. Most importantly, there is urgent need to fast-track progress on the on-going liberalization of the power sector. The induced private competition in the system is expected to spur economic growth and lessen the current fiscal burden on government[8]. The finding of a positive relationship between growth and emissions, however, presents Nigeria with a policy dilemma: attempts to curb emissions could be damaging to growth. Viewing it differently, this could equally imply that Nigeria's growth (or industrialization) processes are highly pollution intensive. Hence, to ensure environmental sustainability, Nigeria may still need to implement a wide range of environmental policies that would induce industries to adopt new technologies, which could help reduce the environmental pollution.

[8] However, we do not subscribe fully to this, at least in the short-term. This is largely because of the special characteristics of the electricity supply market such as its capital intensiveness, long gestation period and spatially distribution networks coupled with current security challenges in the country. These factors may inhibit immediate private sector investment. A declining private sector investment due to any of such reasons requires that government may still need to continue with an active presence in the electricity sector.

The VECM based Granger-causality results confirm a unidirectional short run and long run causality from real income to carbon emissions. There was no evidence of causality from electricity to carbon emissions or from real income to electricity consumption, both in the short run and long run. These results were largely corroborated by the variance decomposition analysis. Fundamentally, the absence of a short-run causality from electricity consumption to real income, and vice versa, does not tend to support the neutrality hypothesis, which implies that, conservative nor expansive policies in relation to electricity consumption in Nigeria have any effect on economic growth. However, we view this as a reflection of the crisis in the Nigerian electricity sector. It could therefore imply that the *neutrality* result is a pointer to the fact that the sector is grossly inefficient in providing the necessary boast to economic growth in the Nigerian case. This tends to be confirmed by the dwindling share of industrial consumption of electricity in Nigeria over the years (Figure 2 refers). This share, which stood at 9.7% in 2008, implies that over 90 % of the electricity requirements by industrial establishments in Nigeria may have come from other sources like expensive backup generators, which is not captured by our data. Our position supports an expansion and improvements in electricity infrastructure and supply in the country, which could probably explained the missing link in the obtained neutrality result.

On the other hand, the finding of a unidirectional causality from economic growth to carbon emissions and of long-term non-causality from carbon emissions and electricity consumption to real income implies that policy measures promoting energy efficiency can be implemented without jeopardizing economic growth. In essence, this signifies that in the long run, efforts should be directed to harnessing energy from other clean sources like natural gas and nuclear renewable to curb emissions. Nigeria also needs to accelerate the energy market reforms and correct the existing energy price anomalies in order to encourage investments in energy infrastructure and discourage wasteful energy usage. In other words, energy conservation is expected to increase the efficient use of energy and thus promotes economic growth and improves environmental quality contemporaneously. The country also need to give adequate boost to energy related research and development for the diffusion of cleaner technologies in the long-run.

References

Acaravci, A., Ozturk, I. (2010), Electricity Consumption-growth nexus: Evidence from panel Data for Transition Countries, *Energy Economics*, 13, 471-483.

Adebola, S.S. (2011). Electricity Consumption and Economic Growth: Trivariate investigation in Botswana with Capital Formation. International Journal of Energy Economics and Policy, 1(2), 32-46.

Akbostanci, E., Turut-Asik, S., Tunc, G.I. (2009), The Relationship between Income and Environment in Turkey: Is there an Environmental Kuznets Curve?, *Energy Policy,* 37, 861-867

Akinlo, A.E. (2009), Electricity consumption and economic growth in Nigeria: Evidence from cointegration and co-feature analysis, *Journal of Policy Modeling, 31, 681-693.*

Akpan, U.F., Chuku, C.A. (2011), "Economic Growth and Environmental Degradation in Nigeria: Beyond the Environmental Kuznets Curve", Paper Presented at the 4th NAEE/IAEE International Conference, Abuja, April.

Akpan, U.F. (2011), Cointegration, Causality and Wagner's Hypothesis: Time Series Evidence for Nigeria (1970-2008), *Journal of Economic Research*, 16, 59-84.

Alan H., Summers, R., Aten, B. (2009), Penn World Table Version 6.3. Center for International Comparisons of production, income and prices, University of Pennsylvania, August, Available freely at pwt.econ.upenn.edu./php-site/pwt63/pwt63-form

Altinay, G., Karagol, E. (2005), Electricity Consumption and Economic Growth: Evidence for Turkey, *Energy Economics*, 27, 849-856.

Ang, J.B. (2007), CO2 emissions, energy consumption, and output in France, *Energy Policy, 35(10), 4772-4778.*

Apergis, N., Payne, J.E. (2011), A Dynamic panel Study of Economic Development and Electricity Consumption-growth Nexus, *Energy Economics,* 33, 770-781.

Apergis, N., Payne, J.E. (2009), CO2 emissions, energy usage, and output in Central America, *Energy Policy, 37, 3282-3286.*

Belsley, D.A., Kuh, E., Welsch, R.E. (1980), *Regression Diagnostics: Identifying Influential Data and Sources of Collinearity.* New York: John Wiley.

CBN (2009), Statistical Bulletin 50 Years Special Anniversary Edition, December, Abuja

Chang, T., Fang, W., Wen, L.F. (2001), Energy Consumption, Employment, Output, and Temporal Causality: Evidence from Taiwan based on Cointegration and Error Correction Modelling Techniques, *Applied Economics,* 33, 1045-1056.

Diao, X.D., Zeng, S.X., Tam, C.M., Tam, V.W.Y.(2009), EKC Analysis for Studying Economic Growth and Environmental Quality: A Case Study in China, *Journal of Cleaner Production,* 17, 541-548

Dinda, S. (2004), Environmental Kuznets Curve Hypothesis: A Survey. *Ecological Economics,* 49, 431-455.

Ekins, P. (1997), The Kuznets Curve for the Environment and Economic Growth: Examining the Evidence. *Environmental Planning,* 29, 805-830.

Esso, L.J. (2010), Threshold cointegration and causality relationship between energy use and growth in seven African countries, *Energy Economics, 32, 1383-1391*

Grossman, G., Krueger, A. (1995), Economic Environment and the Economic Growth, *Quarterly Journal of Economics,* 110, 353-377.

Halicioglu, F. (2007), Residential Electricity Demand Dynamics in Turkey, *Energy Economics,* 29(2):199-210

Halicioglu, F. (2009), An econometric Study of Co2 Emissions, Energy consumption, Income and Foreign Trade in Turkey, *Energy Policy,* 37,1156-1164

He, J., Richard, P. (2010), Environmental Kuznets Curve for Co_2 in Canada, *Ecological Economics*, 69, 1083-1093

Ibitoye, F.I., Adenikinju, A. (2007), Future Demand for Electricity in Nigeria, *Applied Energy,* 84, 492-504

Jamil, F., Ahmad, E. (2010), The Relationship between Electricity Consumption, Electricity prices and GDP in Pakistan, *Energy Policy,* 38, 6016-6025.

Johansen, S., Juselius, K. (1990), Maximum Likelihood estimation and Inference on cointegration-with applications to the demand for money. *Oxford Bulletin of Economics and Statistics*, 52, 169-210.

Jumbe, C.B. (2004), Cointegration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi, *Energy Economics,* 26, 61-68.

Lean, H.H., Symth, R. (2010), CO2 Emissions, Electricity Consumption and Output in ASEAN, *Applied Energy,* 87, 1858-1864.

Mehrara, M. (2007), Energy consumption and economic growth: The case of oil exporting countries, *Energy Policy, 35, 2939-2945.*

Menyah, K., Wolde-Rufael, Y. (2010), Energy consumption, pollutant emissions and economic growth in South Africa, *Energy Economics, 32, 1374-1382*

Narayan, P.K., Smyth, R. (2005). Electricity Consumption, Employment and Real Income in Australia: Evidence from Multivariate Granger Causality tests, *Energy Policy,* 33, 1109-1116.

Narayan, P.K. (2005), The Saving and Investment Nexus for China: Evidence from Co-integration Test. *Applied Economics,* 37, 1979-1990.

Narayan, S., Narayan, P.K. (2004), Determinants of Demand for Fiji's Export: An Empirical Investigation. *The Developing Economies*, XLII-1: 95-112.

Odhiambo, N.M. (2009), Electricity Consumption and Economic Growth in South Africa: A Trivariate Causality test, *Energy Economics,* 31, 635-640.

Olusegun, O.A. (2008), Consumption and Economic Growth in Nigeria: A bounds testing cointegration approach, *Journal of Economic Theory 2(4), 118-123.*

Ozturk, I., Acaravci, A. (2010), CO2 emissions, energy consumption and economic growth in Turkey, *Renewable and Sustainable Energy Reviews, 14, 3220-3225.*

Ozturk, I. (2010), A Literature Survey on Energy-growth Nexus, *Energy Policy,* 38, 340-349.

Pao, H., Yu, H., Yang, Y. (2011), Modelling the CO_2 Emissions, Energy Use, and Economic Growth in Russia, *Energy*, 36: 5094-5100.

Payne, J.E. (2009), On the Dynamics of Energy Consumption and Output in the US, *Applied Energy,* 86, 575-577.

Payne, J.E. (2010), A Survey of the Electricity Consumption-Growth literature, *Applied Energy,* 87, 723-731.

Pesaran, M.H., Shin, Y., Smith, R.J. (2001), Bounds Testing Approaches to the Analysis of Level Relationships, *Journal of Applied Econometrics, 16, 289-326.*

Pesaran, M.H., Shin, Y. (1999), An autoregressive distributed lag modelling approach to cointegration analysis. In: Storm, S. (ed.), *Econometric and Economic theory in 20th Century,* The Ragnar Frisch Centennial Symposium. Cambridge: Cambridge University Press

Robinson, C., Schumacker, R.E. (2009), Interaction Effects: Centering, Variance Inflation Factor, and Interpretation Issues, *Multiple Linear Regression Viewpoints*, 35(1), 6-11.

Romilly, P., Song, H. (2001), Car ownership and use in Britain: A comparison of the empirical results of alternative cointegration estimation methods and forecasts, *Applied economics,* 33,1803-1818.

Sami, J. (2011). Multivariate Cointegration and Causality between Exports, Electricity Consumption and Real Income per Capita: Recent Evidence from Japan. International Journal of Energy Economics and Policy, 1(3), 59-68.

Selden, T., Song, D. (1995), Neoclassical Growth, the J Curve for Abatement, and the Inverted U Curve for Pollution, *Journal of Environmental Economics and Management,* 29: 162-168.

Shiu, A., Lam, P. (2004), Electricity Consumption and Economic Growth in China, *Energy Policy,* 32, 47-54.

Sims, C.A. (1980), Comparism of Interwar and Postwar Business Cycles: Monetarism Reconsidered, *American Economic,* 70, 250-257.

Stern, D.I. (2004), The Rise and Fall of the Environmental Kuznets Curve, *World Development*, 32, 1419-1438.

Tang, C.F. (2008), A Re-examination of the Relationship between Electricity Consumption and Economic Growth in Malaysia, *Energy Policy,* 36(8), 3077-3085.

UNDP/WHO (2009), *The Energy Access Situation in Developing Countries,* New York: UNDP

Wolde-Rufael, Y. (2004), Disaggregated Industrial Energy Consumption and GDP: the Case of Shanghai, *Energy Economics,* 26, 69-75.

Yang, H. Y. (2000), A note on the Causal Relationship between Energy and GDP in Taiwan, *Energy Economics,* 22, 309-317.

Yoo, S. (2005), Electricity Consumption and Economic Growth: Evidence from Korea, *Energy Policy*, 33, 1627-1632.

Yoo, S.H. & Y. Kim (2006), Electricity Generation and Economic Growth in Indonesia, *Energy*, 31(14), 2890-2899.