Prethodno saopštenje

ENERGY CONSUMPTION, ECONOMIC GROWTH AND CARBON-DIOXIDE EMISSION IN WEST AFRICA: A Case Study of Nigeria, Ghana, Togo and Benin

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Abstract:

Energy plays a vital role in economic development of both developing and developed countries. It serves as a key component for sustainable development. Hence, many studies have attempted to look for the direction of causality between energy consumption (EC), economic growth (GDP) and carbon dioxide emissions (C02). This paper, therefore, applies the panel unit root tests, panel co-integration methods and panel causality test to investigate the relationship between these three variables for four West African countries (Nigeria, Ghana, Togo and, Benin) covering the annual period 1970-2012. These West African countries where specifically chosen for our analysis because of their different levels of transition and growth, and also their common interest to boost energy efficiency and diversification through the West Africa Gas Pipeline Project (WAGP).The finding of this study reveals that there is no long-run co-integration relationship amongst our variables neither is there short-run causality running between them. However, in the short-run it is observed that there is a bidirectional Granger causality running from CO2 emissions to EC.

Keywords: West Africa; Energy consumption; Economic growth; CO2 emissions; Panel co-integration; Panel causality; West Africa Gas Pipeline Project (WAGP).

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INTRODUCTION

Over the last few decades, it has become evident at academic and political level, that climate change poses a serious threat to humanity. Consequently, the question of link or the relationship between the global climate change and the level of economic activity has become the major issue and comes to the focal point of research. This is so because human-induced climate change is the most troubling and complex environmental problem facing the world as a whole.

The Earth's climate is changing at an unprecedented rate, and its future implications are wide-ranging, particularly, the security implications of changes in the natural environment. Climate changes are expected to have considerable impacts on natural resource systems, and thereby changes in the natural environment can affect human sustenance or livelihoods (i.e., economic activities). The environmental impact of human activities has grown dramatically because of the sheer increase of world population, energy consumption, industrial activities, urbanization, etc. Policies for reducing energy use alone may not be enough to ensure a certain desired level of environmental quality along with a desired level of economic growth and social welfare especially in developing countries.

To save these developing economies or in other way to protect humanity, proper environmental policy should be adopted at appropriate time (now). One policy options proposed by Kuznet which is highly debatable is to permit a continuous increase in income or economic growth (Environmental Kuznet Curve hypothesis). It is therefore unfortunate, if the very same exploitation that provides us with crucial economic inputs can also be the instrument by which we impair the earth's ability to support life. It therefore implies that in Nigeria, Ghana, Togo and Benin which are highly dependent on fossil fuels, the reduction of carbon dioxide emissions or the de-coupling of economic growth from fossil fuels to secure sustainable low carbon economy represents a serious economic challenge for these economies.

This paper attempts to investigate empirically the long-run and short-run effect of carbon emissions and energy use on economic growth in these 4 West Africa Countries for the period 1970-2012. The structure of this paper is organized as follows: In section II presents theoretical framework, literature and empirical studies. Section III presents the data and methodology used. Empirical results are discussed in Section IV. The final section draws some concluding remarks and suggestions.

1. EMPIRICAL REVIEW

The questionin knowing the causal relationship between energy consumption, CO2 emissions and economic growth of a country or a region has shaped an important query among economists in the literature for some time.Empirical studies on this regards however illustrates conflicting results, so therefore economists' views on this issue have not been unanimous. The causal relationship between energy consumption and GDP has been studied extensively over the past three decades, however the evidence still remains controversial, conclusions on these studies are diverged, ranging from unidirectional or bidirectional to no directional causality.

Empirical studies designed to test the causal relationship between energy consumption and economic growth is generally grouped into three testable hypotheses.

- The first hypothesis suggests that energy consumption is a preconditionfor economic growth given that energy is a direct input in the production process and also, energy is an indirect input that complements labor and capital inputs (Odhiambo, 2009; Ebohon, 1996). Kraft and Kraft (1978) applied a standard Granger causality test. They used theUSA data for the period (1947–1974) and found that a unidirectional long run relationship runs from GDP to energy consumption.

- The second hypothesis assumes that there is a bi-directional or feedback relationship between energy consumption and economic growth. The implication of the bi-directional relationship is that energy consumption and economic growth are complementary. This means that an increase in energy consumption will accelerate economic growth, and contrariwise, an increase in economic growth will stimulate energy consumption (Hou, 2009; Omotor, 2008). Mawuse and Nezan (2009) on the basis of panel data for 4 WAEMU countries for the period (1970-2005) and applying Co-integration test and Vector Error Correction Model (VECM), the findings suggest a bidirectional relationship for the panel as a whole, the findings reveal not only feedback between energy consumption growth nexus but also support regional energy policies which must take account of some countries specificities. Another study conducted using time series data for the period (1970-2009) and applying the techniques of Vector Autoregressive (VAR) and Vector Error Correction Model (VECM), Magazzino (2011) reports the long run bidirectional relationship between energy consumption and economic growth in Italy. Similarly, using time series data from Malaysia for the period 1971-2008 and applying

- The third hypothesis which is neutral, assumes that there is no causality between energy consumption and economic growth and thus policies that are aimed at conserving energy will not retard economic growth (George and Nickoloas, 2011; Ezatollah et al., 2010). Jobert and Karanfil (2007) using time series data for the period (1960-2003) and employing the notion of Granger causality and the notion of instantaneous causality, found no evidence of long run relationship between energy consumption and economic growth which is neutral with each other. The analysis also shows strong evidence of instantaneous causality between these variables.Mulegeta et al (2010) using a panel of forty (40) Sub-Sahara Africa (SSA) countries for the period (1980-2007) and applying a panel Co-integration approach to test the causal relationship between energy consumption and GDP, the findings support the neutrality hypothesis in the short run, except for middle income countries and a strong causation running in both directions is found in the long run. The different results for low and middle income countries provide evidence for the importance of income in the causal relationship.

Over the past three decades, several studies have investigated the causal relationship between CO2 emissions and economic growth. For example, Richmond and Kaufmann (2006) found no significant causality between CO2 emissions and economic growth for 36 nations over the period (1973–1997), which validates the hypothesis of neutrality. Dinda (2009) studied the causal link between CO2 emissions and economic growth for the OECD and non-OECD countries. He concluded that, for the OECD country group, CO2 emission is the cause of growth of income, whereas for the non-OECD country group, the reverse is true.

In contrast to the findings of Halicioglu (2009), Soyas and Sari (2009) found that there was a bi-directional Granger causality (both in short- and long-run) between carbon emissions and income in Turkey. In Nigeria and Venezuela, Soyas and Sari (2009) found a unidirectional causality running from economic growth to CO_2. Similarly, Soyas and Sari (2009) investigated the long-run Granger causality relationship between energy consumption, CO_2 emissions, and economic growth, in Turkey. They found no evidence of a long- run relationship between CO_2 emissions and income.

Arouri et al. (2012) tried first to verify the existence of EKC in twelve (12) Middle East and North Africa (MENA) Countries over the period 1981–2005 and, second to characterize the turning points until which the development improves the environmental quality in these countries. Their results provide poor evidence in support of the EKC hypothesis for MENA countries suggesting that not all MENA countries need to sacrifice economic growth to decrease their emission levels but they may achieve CO_2 emissions reduction via energy conservation without negative long run effects on economic growth. Finally, and by using panel unit root tests and Co-integration techniques to investigate the relationship between carbon dioxide emissions, energy consumption, and real GDP for the 12 MENA countries, they found that energy consumption has a positively significant impact on CO_2 emissions in the long-run and that real GDP exhibits a quadratic relationship with CO_2 emissions for the region as a whole.

Furthermore, Apergis and Payne (2010) explored the relationship between carbon dioxide emissions, energy consumption and real output for eleven (11) countries of the Commonwealth of independent states over the period (1992-2004). They found that in the long-run, energy consumption has a positive and statistically significant impact on carbon dioxide emissions while real output follows an inverted U-shape pattern associated with the Environmental Kuznets Curve (EKC) hypothesis. They found bidirectional causality between energy consumption and CO_2 emissions in the long run. But the short run dynamics reveal a unidirectional direction from energy consumption and real output, respectively, to carbon dioxide emissions and bidirectional causality between energy consumption and real output.

Wang et al., (2011) confirm the existence of a relationship between the three variables using panel Co-integration and panel vector error correction modeling techniques based on the panel data for 28 provinces in China during 1995-2007. They found bidirectional causality between CO_2 emissions and energy consumption as well as between energy consumption and economic growth. The authors also found that energy consumption and economic growth are the long-run causes for CO_2 emissions and CO_2 emissions and economic growth are the long-run causes for energy consumption.

2. RESEARCH METHODOLOGY

There is a huge and growing body of literature exploring the causality relationship between Energy Consumption, Economic Growth and Carbon-dioxide Emission. Amongst these literatures two have proven to stand out:

- **The environmental Kuznets curve (U-Shaped):**

In economics, a Kuznets curve graphs the hypothesis that as an economy develops, market forces first increase and then decrease economic inequality. The hypothesis was first advanced by economist Simon Kuznets in the1950s and '60s. The Environmental Kuznets curve on the other hand is a hypothesized relationship between environmental quality and economic development: various indicators of environmental degradation tend to get worse as modern economic growth occurs until average income reaches a certain point over the course of development.

Although the subject is of continuing debate, some evidence supports the claim that environmental health indicators, such as water and air pollution, show the inverted U-shaped curve (Shafik, Nemat 1994). It has been argued that this trend occurs in the level of many of the environmental pollutants such as , nitrogen oxide, chlorofluorocarbons, lead, sewage, sulfur dioxide, Carbon dioxide and other chemicals previously released directly into the air or water.

- **Energy Consumption Growth Literature**

The direction of causality between energy consumption and income is an important issue for energy economics, economic growth, and policies toward energy use. The motivation for examining the relationship between income and energy consumption first arose in the 1970 when developed countries first proposed significant energy conservation programs.

Income-Energy consumption literature presents a divergence from the empirical economic growth literature, since the primary thread running through the literature since pioneer work of Kraft and Kraft (1978) is the question of whether or not energy consumption causes income or vice versa. If energy consumption causes economic activities, conservation programs would be expected to limit economic activities and the level of income that may be attained.

This study relied on secondary data which was obtained from the World Bank Development Indicators (WDI, 2015). The variables used in this study are Energy Consumption (EC) measured in kg of oil equivalent per capital, GDP per capital measured in constant 2005 US$ and CO2 emissions measured in metric tons per capital. The data set is a balanced panel of four major West African countries over the annual period of 1970 to 2012. The four West African countries included are Nigeria (NG), Ghana (GH), Togo (TG), and Benin (BN).

In order to reduce the heterogeneity of the data among the examined countries, we transform the variables into their natural logarithms. Data is presented using figures and tabulations. The analysis and hypotheses testing were done using regression through the instrumentality of an econometric software package (E-Views 9sv) after which the results were interpreted.

To investigate the relationship between Energy Consumption, CO2 emissions, and economic growth which is a synthesis of the Energy Consumption growth literatures and the Environmental Kuntz Curve (EKC), we need the following variables for all studied West African countries: We empirically investigate the following model based on variables in natural logarithms. The model is specified as;

$$EC = f(GDP, C02)$$

Where;

- EC = Per Capital Energy consumption
- CO2 = Per Capital Carbon dioxide emission
- GDP = Per capita real Gross Domestic Product.

$$EC_{i,t} = \alpha_i + \beta_i GDP_{i,t} + \delta_i C02_{i,t} + e_{i,t} \dots\dots\dots\dots\dots\dots\dots\dots\dots\dots (1)$$

Taking the natural logarithm of both sides of equation (1) and still assuming linearity among the variables gives:

$$LNEC_{i,t} = \alpha_i + \beta_i LNGDP_{i,t} + \delta_i LNC02_{i,t} + e_{i,t} \dots\dots\dots\dots\dots\dots..(2)$$

Where all the above variables are as previously defined and

α_i Is the intercept

β_i *and* δ_i Represents the slope coefficients

e_i Is the stochastic disturbance, or error term.

Coefficients β and represent the long-run elasticity estimates of Energy Consumption with respect to real GDP and real emission respectively.

In analyzing our data set, 4 steps would be employed:

a. Descriptive Statistics

The most modified methodology is that which starts with a descriptive statistics of the variables under observation. According to Mann, Prem S. (1995) Descriptive statistics is the discipline of quantitatively describing the main features of a collection of information, or the quantitative description itself. Observations under a descriptive statistics include the mean, median, maximum and minimum, standard deviation,skewness, kurtosis, and jarque-bera.

b. Panel unit root testing

The body of literature on panel unit root and panel co-integration testing has grown considerably in recent years and now distinguishes between;

(i) The first-generation tests [Maddala and Wu (1999), Levin et al. (2002) and Im et al. (2003)] developed on the assumption of the cross sectional independence of panel units (except for common time effects),

(ii) The second-generation tests [Bai and Ng (2004), Smith et al. (2004), Moon and Perron (2004), Choi (2006) and Pesaran (2007)] allowing for a variety of dependence across the different units, and also

(iii) Panel data unit root tests that make it possible to accommodate structural breaks.

In addition, in recent years it has become more widely recognized that the advantages of panel data methods within the macro-panel setting include the use of data for which the spans of individual time series data are insufficient for the study of many hypotheses of interest.

For the purposes of our analysis we begin by testing for the presence of stationarity in the variables analyzed: Energy Consumption, C02 emission, and GDP. The recent literatures propose several methods for unit root tests in panel data analysis. Since these methods may give different results, we have selected six different unit root tests to be able to make deceive conclusions. These tests include:

	H0	H1
1. (2002) (LLC's), t-statistics.	Panel data has unit root (assume common unit root process) (Non-Stationary)	Panel data has no unit root (Stationary)
2. Breitung (2000) t-statistic. 3. Im, Perasan and Shin (2003) (IPS), W-statistic.	Panel data has unit root (assume common unit root process) (Non-Stationary)	Panel data has no unit root (Stationary)
4. Augmented Dickey Fuller - Fisher Chi-square test (ADF - Fisher),	Panel data has unit root (assume individual unit root process) (Non-Stationary)	Panel data has no unit root (Stationary)
5. Phillips and Perron (1988), PP-Fisher Chi-square tests.	Panel data has unit root (assume individual unit root process) (Non-Stationary)	Panel data has no unit root (Stationary)
6. Hadri (2000).	Panel data has no unit root (assume common unit root process) (Stationary)	Panel data has unit root (Non-Stationary)

c. Panel co-integration analysis

Once the order of stationarity has been defined in our panel unit root test, and proves to be non-stationary at Level and stationary at First Difference, the next step is to determine whether the regressions are spurious, and this can be achieved by conducting a panel co-integration tests. In other to test for these co-integrating relationships, three types of panel co-integration tests would be conducted.

- The first test developed by Pedroni (1999, 2004) proposed seven panel co-integration statistics under null hypothesis. The seven tests are based on the absence of co-integration.
- The second test conducted is the residual based panel co-integration test developed by Kao (1999) proposed to estimate the homogeneous co-integrating relationship.
- The third panel co-integration test we apply is the Johansen (1988) panel co-integration test developed by Maddala and Wu (1999). This test is based on the co-integration trace and maximum eigenvalue test by Johanson (1991).

The below equation describes a co-integrated panel regression that allows for heterogeneity in the pane slope coefficient and deterministic trend. (Pedroni, 1999, 2004). Finally, are the parameters of the model to be estimated and are the residuals.

$$LNEC_{i,t} = \ddot{\alpha}_i + \beta_i LNGDP_{i,t} + \delta_i LNCO2_{i,t} + e_{i,t} \dots\dots\dots\dots\dots\dots\dots\dots . (3)$$
$$\text{Where } i = 1, \dots\dots\dots\dots, N \text{ and } t = 1, \dots\dots\dots\dots\dots\dots ., T$$

d. Panel causality analysis

In order to investigate the short and long-run dynamic relationships on panel data among the variables of energy consumption, C02 emissions and economic growth, we adopt two steps. Firstly, if the panel variables are integrated (unit root) and co-integrated, the direction of causality can be detected through the Vector Error Correction model (VECM) of the long-run co-integrating vectors. On the other hand if the variables are integrated (unit root) and not co-integrated, the Vector autoregressive model (VAR) is used to detect the direction of causality. Secondly, Granger Causality testing would be performed to summarize the result of either of the models described above. The resulting equation is as follows:

$$\Delta LNEC_{i,t} = \theta_{1,t} + \sum_{k=1}^{m} \theta_{1,1,i,k}.\Delta LNEC_{i,t-k} + \sum_{k=1}^{m} \theta_{1,2,i,k}.\Delta LNGDP_{i,t-k} + \sum_{k=1}^{m} \theta_{1,3,i,k}.\Delta LNC02_{i,t-k} + \lambda_{1,t}.ECT_{i,t-1} + U_{1,i,t} \dots\dots\dots\dots\dots\dots\dots\dots\dots.(4)$$

$$\Delta LNGDP_{i,t} = \theta_{2,t} + \sum_{k=1}^{m} \theta_{2,1,i,k}.\Delta LNEC_{i,t-k} + \sum_{k=1}^{m} \theta_{2,2,i,k}.\Delta LNGDP_{i,t-k} + \sum_{k=1}^{m} \theta_{2,3,i,k}.\Delta LNC02_{i,t-k} + \lambda_{2,t}.ECT_{i,t-1} + U_{2,i,t} \dots\dots\dots\dots\dots\dots\dots\dots\dots.(5)$$

$$\Delta LNC02_{i,t} = \theta_{3,t} + \sum_{k=1}^{m} \theta_{3,1,i,k}.\Delta LNEC_{i,t-k} + \sum_{k=1}^{m} \theta_{3,2,i,k}.\Delta LNGDP_{i,t-k} + \sum_{k=1}^{m} \theta_{3,3,i,k}.\Delta LNC02_{i,t-k} + \lambda_{3,t}.ECT_{i,t-1} + U_{3,i,t} \dots\dots\dots\dots\dots\dots\dots..(6)$$

Where the term Δ denotes first differences; (j=1,2,3) represents the fixed country effect; k (k=1,…,m) is the optimal lag length determined by the Schwarz Information Criterion; and is the estimated lagged error correction term derived from the long-run co-integrating relationship of Eq. (1). The term (j=1, 2, 3) is the adjustment coefficient and is the disturbance term assumed to be uncorrelated with zero means.

3. DATA ANALYSIS AND PRESENTATION

Due to the non-stationary nature of most economic time series data, a unit root test has to be carried out to test for stationary. This is because running regression with non- stationary time series data will likely give us a spurious result which will make any economic conclusion made from it to be invalid. Thus, this study is carried out using six (6) Panel Unit Root Tests.

Table 1. Panel Unit Root Test

Method	LNGDP	LNEC	LNC02
LLC-t*			
Level	1.97312 (0.9758)	0.02592 (0.5103)	-0.38037 (0.3518)
First Difference	-9.16268 (0.0000)***	-11.9955 (0.0000)***	-10.1276 (0.0000)***
Breitung-t-sat			
Level	2.44176 (0.9927)	-0.51996 (0.3015)	-1.99348 (0.0231)
First Difference	-7.26500 (0.0000)**	-9.24511 (0.0000)**	-7.19794 (0.0000)**
IPS-W-stat			
Level	2.18849 (0.9857)	0.35465 (0.6386)	-2.16421 (0.0152)
First Difference	-9.48032 (0.0000)**	-11.0513 (0.0000)**	-11.5546 (0.0000)**
ADF-Fisher			
Level	2.54186 (0.9598)	6.17265 (0.6279)	24.9923 (0.0016)
First Difference	85.3558 (0.0000)**	101.812 (0.0000)**	108.127 (0.0000)**
PP-Fisher			
Level	2.63562 (0.9551)	6.20232 (0.6246)	25.5753 (0.0012)
First Difference	92.6013 (0.0000)**	102.892 (0.0000)**	138.832 (0.0000)**
Hadri – Z stat			
Level	2.34099 (0.0096)**	6.25411 (0.0000)**	6.89412 (0.0000)**
First Difference	2.76609 (0.028)	0.01632 (0.4935)	-0.47892 (0.6840)

Notes: *LLC, IPS, ADF-Fisher and PP-Fisher and Breitung examines the null hypothesis of non-stationarity which indicates the presence of a unit root at level, except for Hadri test which has no unit root (stationarity) in the panel* *series at Level. The number of parenthesis denotes P value. ** and * denotes the rejection of the null hypothesis at the 5% and 10% level of significance. Probabilities for Fisher-type tests were computed by using an asymptotic χ 2 distribution. All other tests assume asymptotic normality. The lag length is selected using the Modified Schwarz Information Criteria. All variables are in natural logarithms (LN).*

The evidence from the result above suggests that the variables in question do evolve as non-stationary in their Level form except for C02 emission which appears to be stationary at 1% and 5% level of significance in some of the test processes. On the other hand, all variables become stationary in their First Difference at 5% level of significance. This implies that the application of OLS (Ordinary Least Square) estimation technique to the above equations will result in biased and inconsistent estimates. It is therefore necessary to turn to panel co-integration estimation techniques in order to determine whether a long-run equilibrium relationship exists among the non-stationary variables in level form.

Table 2.Pedroni (2004)'s residual co-integration test results (LNEC as dependent variable)

	Test Statistics	**Probability**		**Test Statistics**	**Probability**
Within Dimension			**Between Dimension**		
Panel v-sat	-0.589940	0.7224			
Panel r-sat	0.245069	0.5968	**Group r-sat**	1.145696	0.8740
Panel PP-sat	0.228934	0.5905	**Group PP-sat**	0.624004	0.7337
Panel ADF-sat	0.272492	0.6074	**Group ADF-sat**	0.662456	0.7462

Notes: *The null hypothesis is that the variables are not co-integrated. Under the null tests, all variables are distributed normal (0, 1). ** and * indicates statistical significance at the 5% and 10% level.*

As shown in the Table above, the results of Pedroni's (2004) heterogeneous panel tests indicate that the null of no co-integration cannot be rejected at 5% or 10% level of significance for the seven (7) tests carried out. This indicates that the variables in our panel data under the Pedroni's test (EC, GDP, and C02) have no co-integrating long run relationship what so ever.

Table 3.Kao (1999)'s residual co-integration test results (LNEC as dependent variable)

	t-statistics	**Probability**
ADF	0.798739	0.2122

Note: *The null hypothesis is that the variables are not co-integrated. ** and * indicates statistical significance at the 5% and 10% level.*

The table above reports the results of Kao's (1999) residual panel co-integration tests. From the result above, our p-value is 21.2%. This indicates that we cannot reject the null of no co-integration at the 5% or 10% level of significance.

Table 4. Panel co-integration test results of Fisher test using an underlying Johansen (1988)'s methodology

	Fishers statistics (from trace test)	**Probability**
None	11.18	0.1914
At almost 1	5.151	0.7414
At almost 2	4.917	0.7664

Notes*: The null hypothesis is that the variables are not co-integrated. Asymptotic p-values are computed using $\chi 2$ distribution. ** and * indicates statistical significance at the 5% and 10% level. Fisher (1932)'s test applied regardless of the dependent variable*

Finally, the results of Johansen's (1988) Fisher panel co-integration test reported in the table above, are based on Fisher's tests (trace test statistics) and support the absence of a co-integrated relationship between the three variables at the 5% and 10% level of significance respectively. However the result also accepts the null hypothesis of a co-integration relationship between at most one (1) or two (2) of the variables in our panel at the 5% and 10% level of significance. Thus, we conclude the absence of a panel long-run co-integration relationship between these three variables, meaning that energy consumption, real income (GDP), and the CO2 emissions do not move together in the long run in our panel. Based on the co-integration result obtained from the three tests of Pedroni, Kao and Fisher, it is clear that there is no long-run co-integrating relationship among the three variables (energy consumption, gross domestic product and carbon-dioxide emission) in our panel data. Thus a Vector Auto regression analysis would be performed to determine the direction of causality in our variables and a Granger Causality test to summarize its results.

Table 5. Vector Auto Regression Test Result (2 Lags)

Dependent Variables	**Sources of Causation (Independent Variables)**		
	DLNEC	**DLNGDP**	**DLNC02**
DLNEC(-1)	------	0.15826 (0.8743)	1.63868 (0.1020)
DLNEC(-2)	------	-0.46588 (0.6415)	-1.34664 (0.1788)
DLNGDP(-1)	1.12243 (0.2623)	------	0.06869 (0.9453)
DLNGDP(-2)	0.62588 (0.5317)	------	1.37364 (0.1702)
DLNC02(-1)	-1.09452 (0.2743)	1.45437 (0.1465)	-------
DLNC02(-2)	-1.71807 (0.0865)*	-1.04038 (0.2987)	-------

***Notes**: Figures denote T-statistic values. P-values are in parentheses. ** and * indicates statistical significance at the 5% and 10% level*

From the table above, we cannot find evidence of a short-run causality running from DLNEC and DLNCO2 to LNGDP in both lags at 5% and 10% level of significance. This implies that economic growth will not be influenced by energy consumption and CO2 emissions in the short run. Also there is no short-run causality running from DLNEC and DLNGDP to DLNC02 in both lags at 5% and 10% level of significance. This implies that CO2 emissions will not be influenced by economic growth and energy consumption in the short run. Finally we can see a weak causality running from DLNC02 to DLNEC in the second lag.

Table 6. VAR Granger Causality/Block ExogeneityWald Tests

Dependent Variable: DLNEC			
Independent Variable	**Chi Square**	**Difference**	**Probability**
DLNGDP	1.826304	2	0.4013
DLNC02	3.178376	2	0.2041
All	4.469860	4	0.3461
Dependent Variable: DLNGDP			
Independent Variable	**Chi Square**	**Difference**	**Probability**
DLNEC	0.253359	2	0.8810
DLNC02	5.088336	2	0.0785*
All	5.399797	4	0.2487
Dependent Variable: DLNC02			
Independent Variable	**Chi Square**	**Difference**	**Probability**
DLNGDP	4.823236	2	0.0897*
DLNEC	1.935127	2	0.3800
All	6.666978	4	0.1546

Notes: ** indicates statistical significance at the 10% level*

Based on the result of the Granger causality test above, we can conclude that GDP and C02 emission does not granger cause EC. Furthermore, EC and C02 does not granger cause GDP, and finally, Energy consumption and GDP does not granger cause C02 emission. Notwithstanding we can see that there is a bidirectional causality running from GDP to C02 Emission at a weak 10% level of significance. This implies that in the short run, a shift in Economic growth would affect the amount the C02 emitted and vice versa.

4. FINDINGS

From the analysis of the results in chapter four our hypothesis can be tested. The following facts could be deduced:

Hypothesis 1: This hypothesis states that there is a long-run co-integration relationship between energy consumption, economic growth, and C02 emission in the panel time series. From our analysis in chapter four, using 3 types of co-integration techniques (Pedroni, Kao and Fisher) we can clearly reject the hypothesis of a co-integration relationship amongst these three variables in our panel. This is to say that in the long run energy consumption, C02 emission and economic growth do not move together. A change in economic growth and C02 emission would not affect energy consumption and vice versa.

Hypothesis 2: This hypothesis state that short-run causality runs from economic growth to energy consumption and CO2 emissions (also known as growth led hypothesis or conservatory hypothesis). This is to say that in the short run the three variables move together

From the VAR Granger causality test conducted in the previous chapter, we can clearly reject the hypothesis of a short-run causality between these three variables at a 5% and 10% level of significance and accept the hypothesis of neutrality. Meaning that GDP and C02 emission do not Granger cause EC in the short run, so also GDP and EC do not Granger cause C02 in the short run, and C02 and EC taking together do not Granger cause GDP in the short run in our panel.Thus policies that are aimed at conserving energy will not retard economic growth (George and Nickoloas, 2011; Ezatollah et al., 2010). This implies that the countries in our panel data do not need to sacrifice economic growth to decrease their C02 emission levels but they may achieve emissions reduction via energy conservation without negative long run effects on economic growth.

Hypothesis 3 and 4: This hypothesis assumes a bidirectional or feedback causality relationship between energy consumption, economic growth and CO2. The implication of the bi-directional relationship is that energy consumption, economic growth and C02 emission are complementary. This means that an increase in energy consumption will accelerate economic growth and C02 emission contrariwise; an increase in economic growth will stimulate energy consumption and C02 emission and so on (Wang et al., 2011).

The result of our VAR Granger causality above only shows a weak bi-directional Granger causality running from EC to C02. That is to say EC Granger causes C02 emission and likewise C02 emission Granger causes EC.

5. POLICY RECOMMENDATIONS AND DISCUSSION

The results of this study do not support any of the hypothesis stated in the introduction. Rather, only a bi-directional causality was seen between energy consumption to C02 emission. In view of this, the following policies are recommended based on the research findings, taking into account the developmental stages of the countries in our panel. Although the result of our panel case shows no short-run or long-run causality amongst the three variables in the panel data, the adoption of conservation policies (such as the phasing out of energy subsidies) as a viable option may not apply effectively because economic situations differ from country to country. Nigeria, Ghana, Togo and Benin are developing country with medium level of industrialization. In Nigeria, Ghana, Togo and Benin only about 56%, 64%, 31% and 38% of the population have access to modern electricity. Considering the above factors the goal of conservation should not be to reduce the total consumption but to increase the efficiency of energy consumption.

Considering the foregoing, the following policy recommendations are made to enhance energy efficiency in Nigeria, Ghana, Benin and Togo.

- **Use of Energy-saving Appliances**:

Promoting the use of energy-saving appliances such as compact fluorescent lamps (CFLs) may be considered for our panel case. This can be realized through the provision of tax incentives on the importation of energy-saving products while increasing the importation tax on other appliances regarded as inefficient-energy-use appliances. The adoption of such energy conservation policies will enable the end users to save on the cost of their electricity purchases. Such practices can also increase the government revenue savings, which can be directed towards importing energy-efficient technologies for the rural sectors, where access to the national grid has proven to be difficult, or used to boost industrial activities and to educate the public on the benefits of energy efficiency enhancement.

- **Increased Operational Efficiency:**

Energy conservation can also be achieved by ensuring that there is a considerable reduction in the waste generated in the process of the production, supply, and use of energy services across the energy supply chain. In the process of the generation and supply of energy, high system losses of up to 10% were recorded for Nigeria. Ghana, Togo and Benin had an estimate of 23% and 83% are encountered respectively, especially during electric power supply. To reduce the generated losses, the consistent maintenance and use of new and modern energy technologies, infrastructure, and plants can enhance the efficiency levels leading to a reduction in losses (Energy Commission, 2012). Thus, to achieve economic viability and to enhance efficiency, the refinery use capacity has to be increased.

- **Regulation of the Power Supply Sector:**

Aside from technical losses, the power sector also suffers from commercial losses. This results from the non-payment of electricity bills, non-collection of electricity bills, illegal power connections, and pilfering. Commercial losses during supply services are rampant and need critical attention. This can be curbed by setting up monitoring mechanisms or meters that can automatically detect theft and illegal connections. Subsequent to this practice, penalties could be awarded to offenders. Additionally, the electricity distribution sector can be privatized (Ghana, Togo and Benin) to make the sector competitive and to enhance the efficiency in the sector's operations.

CONCLUSION

The principal aim of this paper was to seek for the linkages between energy consumption, economic growth and carbon emissions in 4 West African countries (Nigeria, Ghana, Togo, and Benin) and during the period starting from 1970 to 2012. These West African countries where specifically chosen for our analysis because of their different levels of transition and growth, and also their common interest to boost energy efficiency and diversification through the West Africa Gas Pipeline Project (WAGP). We employed in this study the panel unit root, panel co-integration method and panel causality test.

Our panel unit root test reveals the presence of unit root at level in the three variables. This implies that that the variables in question do evolve as non-stationary in their level form, but when taken in their first difference they emerge as stationary. Our panel co-integration test further reveal that there is no evidence of a panel long- run equilibrium co-integration relationship between energy consumption, real income (GDP), and the CO2 emissions, meaning that these three variables do not move together in the long run in our series.

Finally, a panel-based on Vector Autoregressive model (VAR) was further employed to investigate the short-run dynamic relationships. In sum, our empirical results show that in the short run, there is no evidence of a granger causality running from economic growth and CO2 emissions taken together to energy consumption, neither is there a short-run causality running from energy consumption and economic growth taken together to CO2 emissions nor a causality running from economic growth and C02 emission taken together to energy consumption. We further found a short-run bi-directional causality running from energy consumption to C02 emission. This implies that energy consumption granger causes C02 emission and vice versa.

The results of this study do not support any of the hypothesis stated in the introduction. Rather, only a bi-directional causality was seen between energy consumption to C02 emission. In view of this, the following policies are recommended based on the research findings, taking into account the developmental stages of the countries in our panel. Although the result of our panel case shows no short-run or long-run causality amongst the three variables in the panel data, the adoption of conservation policies (such as the phasing out of energy subsidies) as a viable option may not apply effectively because economic situations differ from country to country. Nigeria, Ghana, Togo and Benin are developing country with medium level of industrialization. In Nigeria, Ghana, Togo and Benin only about 56%, 64%, 31% and 38% of the population have access to modern electricity. Considering the above factors the goal of conservation should not be to reduce the total consumption but to increase the efficiency of energy consumption.

Considering the foregoing, the following policy recommendations are made to enhance energy efficiency in Nigeria, Ghana, Benin and Togo.

- Use of Energy-saving Appliances:
- Increased Operational Efficiency:
- Regulation of the Power Supply Sector

In conclusion, developing West African economies face a two-fold energy challenge in this 21st century: Meeting the needs of billions of people who still lack access to basic, modern energy services while simultaneously participating in a global transition to clean, low-carbon energy systems. In other to achieve this, the efforts toward increased efficiency, de-carbonization, greater fuel diversity and lower pollutant emissions need to be greatly accelerated.

To a significant extent, fortunately, the goal of reducing greenhouse gas emissions may be aligned with the pursuit of other energy-related objectives, such as developing indigenous renewable resources and reducing local forms of pollution. Governments should look across policies to maximize positive synergies where they exist.

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