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ENERGY CONSUMPTION AND ECONOMIC GROWTH: EMPIRICAL EVIDENCE FROM WEST AFRICA

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Abstract

Energy can either limit or accelerate production processes and consequently economic growth. This study investigated the validity of any of the four hypotheses (conservation, growth, feedback and neutrality) formulated in the study of the relationship between energy consumption and economic growth. This study analyzed these hypotheses in West African context by applying the stationarity tests and Pedronicointegration as well as causality tests (Granger-Causality, Vector Autoregressive (VAR) Causality and Toda-Yamamoto Causality) and regression analysis (Ordinary Least Squares (OLS), Panel Fully Modified Least Squares (FMOLS) and Dynamic Least Squares (DOLS)) in accomplishing the investigation. The study found per capita GDP to Granger cause energy consumption in West Africa and the Causality runs from per capita GDP to energy consumption. Energy consumption (EPC) and Gross Domestic Product per capita (GDPPC) are positively related. Economic growth significantly explains energy consumption in West Africa. A dollar increase in Per Capita GDP other things being constant will cause energy consumption to increase by 0.03 US dollar. Based on the above therefore, since economic growth implies more energy consumption, and at present, energy consumption in West Africa is predominantly fossil-based which is unsustainable as it is non-renewable. West African governments must work to encourage more energy efficient production processes. In addition to this, government must put up policies to generate and utilize more renewable energy. This will reduce the pollution associated with fossil-based energy sources.

Keywords: Economic growth, Energy consumption, Energy efficiency.

JEL Classifications: Q32, Q43, Q57

Introduction

Energy is a major input that is utilized in all stages of production and it is an important resource consumed as an output for increasing people's welfare. It is one of the major determinants of economic and social development. According to Stern (2010) energy can either limit or accelerate production processes and consequently economic growth based on two main factors. The first is the ease of energy procurement.

Secondly is the state of technology which ultimately determines energy efficiency. Another dimension in the energy consumption - growth relationship is the issue of energy sustainability. In view of greater demand for energy possibly implied by economic growth; with the present consumption of non-renewable energy sources, is the present consumption rate supportive of future energy demand? In addition, What is/(are) the environmental consequence(s) of depending on fossil fuels?

West Africa has a total population of about 340 million but has the lowest modern electricity consumption in the World. Access to electricity in West Africa region ranges from 20 percent to 50 percent (Energy situation report- West Africa). Nigeria is the largest country in West Africa and an estimated 96 million people (which is about 55 percent of its population) are without access to electricity. In the whole ECOWAS region, 19 percent of rural populace only have access to electricity. The reasons adduced to lack of access to electricity includes: regulatory, social, technical and economic as well as financial problems. Others include insufficient power generation, high petroleum prices and; transmission and distribution losses (Energy situation report - West Africa).

According to Oxfam international (2020), in comparison with other region in Africa, more than 30 percent of West African countries are living on less than $1.90 a day. According to the economic commission for Africa (ECA, 2004), despite the abundant endowment of West African region with energy resources such as hydro, wind, solar, biomass and other resources that can be harnessed to meet the domestic demand for energy, especially electricity; the supply of electricity in West Africa is very low. About two- thirds of the populace lack electricity (International Energy Agency, 2014). According to Twerefou, Iddrisu and Twum (2018), with the energy challenge of the sub region, economic growth has been so stagnant especially in the 1990s. The growth estimates is put at about 3 percent. This is as a result of the impact of the biggest economy (Nigeria) which is pulling down the rate as well as the role played by the political instability in the sub region.

The economic growth of the region has been distorted or stagnated. The question is; is there any connection between consumption of energy and economic growth of the region? Which one causes the other? An empirical answer to these questions will guide policymakers on the choice of intervention policies that can propel the potentials of the region to attain growth. According to Apergis and Payne (2012), there are four postulated hypotheses proposed on the relationship between consumption of energy and attainment of economic growth. The first one is the conservation theorists that postulate that economic growth determines the level of energy consumption. The second group is the growth theorists who are of the opinion that consumption of energy drives economic growth. The third hypothesis is known as feedback theorists that stated that there is interdependence between energy consumption and economic growth.

In other words, energy consumption aids growth on one hand and; economic growth propel energy consumption at the other hand. The fourth hypothesis is the neutrality school that assumed that energy consumption has very minor role to play in the issue of economic growth. (Ucan, Aricioghu and Yucel, (2012).

Although the casual relationships as well as the effects of energy consumption on economic growth have been widely researched on, however, there is no general consensus on energy consumption-economic growth nexus (Alam, Begum, Buysse and Huylenbroeck, 2012). It is the focus of this study therefore, to conduct research on the validity or otherwise of any of the four hypotheses (conservation, growth, feedback and neutrality) in West Africa with a view to making good policy intervention that may propel economic growth in West Africa.

This study therefore applied causality tests and regression analysis in accomplishing the investigation. The synopsis of this study is as follows: The next section deals with review of literature, followed by the research methodology, then results and discussions, lastly is the conclusion and recommendation.

Literature Review

According to Atif and Siddiqi (2010) electric energy is an important factor driving productivity in various sectors of most economies of the world. Supporters of positive link between energy and economic growth argued that sustained energy supply propels productivity which ultimately enhances economic growth. Therefore, energy supply (Consumption) Granger causes economic growth in emerging economies other things being constant (Wolde-Rufael, 2004). According to Ucan, Aricioghu and Yucel (2012) energy is an essential factor of production just like capital and labour irrespective of the categorization of the country (developing or developed). Yet there are those that belong to the neutrality school that assumed that energy consumption has very minor role to play in the issue of economic growth (Solow, 1974). This study therefore explored some earlier studies on the relationship of energy consumption - economic growth so as to understand the extent of literature on them and to be guided in this study.

Quedraogo (2013) tested the long-run relationship between energy consumption and economic growth for fifteen West African countries using data spanning from 1980-2008 and analyzing unit root tests, cointegration and granger casualty. The study tested the relationship between energy prices, energy consumption and economic growth. It also tested the relationship between electric consumption, its prices and economic growth. The study found among others that GDP, consumption of energy and; electricity consumption move together. There is a unidirectional casualty from GDP to consumption of energy in the short run and; there is casualty from consumption of energy to GDP in the long run. There is also a unidirectional casualty from electricity consumption to GDP in the long run.

Tariq, Sum, Haris, Javaid and Kong (2018) conducted investigation on the relationship between economic growth and energy consumption in India, Pakistan, Sri Lanka and Bangladesh from 1981 to 2015 using the methods of instrumental variables. The study modeled energy consumption as related to urban population, growth, FDI and trade. The study found that increasing economic growth tends to increase energy consumption. Trade negatively correlates with energy consumption leading to energy efficient technology. Lastly, the countries studied are energy dependent and prone to energy supply shocks.

Sahoo and Sethi (2020) explored the relationship existing between energy consumption, urbanization, industrialization, financial development and economic growth in India from 1980 to 2017 using the cointegration, regression, error correlation and casualty model. They found that industrialization, urbanization and economic growth plays vital role in increasing energy consumption in India in the long run. Financial development exerted negative effect on energy consumption. Toda-Yamamoto casualty results suggested that there existed a unidirectional casualty running from industrialization to energy consumption. There is a bi-directional casualty between energy consumption and; urbanization, energy consumption and; economic growth.

Shahbaz, Chaudery and Ozturk (2017) investigated the relationship between urbanization - energy consumption in Pakistan from the first quarter of 1972 and fourth quarter of 2011 using statistic impact by regression on population, affluence and technology model (STIRPAT), VECM Granger casualty. Their results indicated that urbanization drives energy consumption. It also found that economic growth increases energy demand. Technology is directly related to energy consumption. They also found a unidirectional casualty from urbanization to energy consumption in Pakistan.

Ochada and Ayadi (2020) examined the level of association among energy consumption, air pollution and economic growth in Nigeria between 1970 and 2017. Using Vector autoregression (VAR) method the study found the GDP per capita shock exerted positive impact on electricity consumption both in the short and long run. There is a negative shock of carbon dioxide (CO2) and nitrous oxide (NO2) variables to economic growth among others.

Park and Yoo (2013) examined the casual link between oil consumption and economic growth in Malaysia between 1965 and 2011 using the method of co integration and Granger-casualty based on the error correction models. They found the existence of a bi-directional casualty between economic growth and oil consumption in Malaysia. They concluded that more oil consumption propels economic growth directly.

Rahman, Farihama and Norma (2017) investigated the relationship between economic growth and; disaggregated energy consumption in the long run in Malaysia between 1971 and 2014 using the method of Toda-Yamamoto (T-Y), and the modified Granger casualty. The study found that Malaysia is energy dependent economy where energy is inefficiently utilized. Higher energy consumed bear no direct impact on economic growth but rather act to worsen the environment.

There is a positively significant impact of economic growth on environmental degradation. They recommended that Malaysia should put up measures to ensure energy efficiency.

Muse (2014) examined the relationship between the consumption of energy and economic growth in Nigeria between 1980 and 2012 using cointegration, Ordinary Least Squares, Error Correction Model and Granger casualty. The study found a bi-directional casualty between energy consumption and economic growth in Nigeria. The results also indicate that consumption of energy also enhances economic growth in Nigeria and suggested that government must put in place policies to boost power supply so as to promote economic growth in Nigeria.

Twerefou, Iddrisu and Twum (2018) explored the effects of total energy consumption, electricity consumption and petroleum consumption on economic growth in seventeen West African countries using panel data spanning from 1980 to 2015 and analyzing using the cointegration, casualty and least squares (FMOLS and DOLS).

The study found that there is no causality in the short-run running from; total energy, electricity and petroleum consumption to economic growth. However, there is a unidirectional relationship from economic growth to electricity consumption indicating electricity conservation may have no effect on growth. In the long run, petroleum consumption as well as electricity consumption have exerted significant positive effect on economic growth.

Based on the review above, the effects of energy consumption on economic growth is far from being resolved as results are not unanimous even for the same country. Studies differ in terms of methodology, choice of variables, models and study horizon, this study therefore is set to conduct its analysis bearing in mind some perceived flaws of previous studies.

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Methodology

This study utilized causality and regression to answer the questions of this research. To conduct the causality test, the study estimated the models below after conducting the stationarity test on the variables and conducted the Pedronicointegration test. Conducting the null hypothesis of GDPPC does not cause EPC, we simply run equations 1 and 2 as:

$$EPC_t = \sum_{i=1}^{m} \alpha_i EPC_{t-i} + \sum_{i=1}^{n} \beta_i GDPPC_{t-i} + e_t \qquad ---(1)$$

$$EPC = \sum_{i=1}^{m} \alpha_i EPC_{t-i} + e_t \qquad ---------(2)$$

We then proceed by testing the significance of αi = 0 for every **i**.

There are two conditions for the traditional Granger casualty to work. The first is that all variables must be integrated of order zero. The other condition is for all variables to be integrated of order one (Domitrescu and Hurlin, 2012). However, Toda and Yamamoto (1995) argued that with one or more variables not stationary, the traditional Granger casualty test based on Domitrescu and Hurlin (2012) is not valid based on Wald test statistic that does not follow its usual asymptotic chi-square distribution based on the null hypothesis. To overcome the problem, Toda-Yamamoto introduced additional d + d_{max} to the time series Vector Autoregression (VAR) (k) to achieve asymptotic distribution of the Wald test statistics. Toda-Yamamoto approach is suitable for heterogeneous panel data. The test statistics based on VAR causality and Toda-Yamamoto are hereunder presented.

Vector Autoregressive (VAR) Causality Model

$$EPC_t = \alpha_0 + \sum_{i-1}^{k} \alpha_{1i} EPC_{t-i} + \sum_{i=1}^{k} \alpha_{2i} GDPPC_{t-i} + \sum_{i=1}^{k} \alpha_{3i} GCF_{t-i} + \sum_{i=1}^{k} \alpha_{4i} LABPR_{t-i} + \varepsilon_{1t} ---(3)$$

$$GDPPC_t = \beta_0 + \sum_{i-1}^{k} \beta_{1i} EPC_{t-i} + \sum_{i=1}^{k} \beta_{2i} GDPPC_{t-i} + \sum_{i=1}^{k} \beta_{3i} GCF_{t-i} + \sum_{i=1}^{k} \beta_{4i} LABPR_{t-i} + \varepsilon_{2t} ---(4)$$

$$GCF_t = \delta_0 + \sum_{i-1}^{k} \delta_{1i} EPC_{t-i} + \sum_{i=1}^{k} \delta_{2i} GDPPC_{t-i} + \sum_{i=1}^{k} \delta_{3i} GCF_{t-i} + \sum_{i=1}^{k} \delta_{4i} LABPR_{t-i} + \varepsilon_{3t} ---(5)$$

$$LABPR_t = \phi_0 + \sum_{i-1}^{k} \phi_{1i} EPC_{t-i} + \sum_{i=1}^{k} \phi_{2i} GDPPC_{t-i} + \sum_{i=1}^{k} \phi_{3i} GCF_{t-i} + \sum_{i=1}^{k} \phi_{4i} LABPR_{t-i} + \varepsilon_{4t} ---(6)$$

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In equation three for instance; VAR Causality test involves the following decisions among others:

GDPPC is said to Granger- cause EPC if $\alpha_{2i} \neq 0$, otherwise it does not.

GCF is said to Granger-cause EPC if $\alpha_{3i} \neq 0$, otherwise it does not.

LABPR is said to Granger-cause EPC if $\alpha_{4i} \neq 0$, otherwise it does not.

Toda-Yamamoto Causality Model

$$EPC_t = \alpha_0 + \sum_{i-1}^{k} \alpha_{1i} EPC_{t-i} + \sum_{j=k+1}^{k+d\max} \alpha_{2j} EPC_{t-j} + \sum_{i=1}^{k} \beta_{1i} GDPPC_{t-i} + \sum_{j=k+1}^{k+d\max} \beta_{2j} GDPPC_{t-j} + \sum_{i=1}^{k} \delta_{1i} GCF_{t-i}$$
$$+ \sum_{j=k+1}^{k+d\max} \delta_{2j} GCF_{t-j} + \sum_{i=1}^{k} \phi_{1i} LABPR_{t-i} + \sum_{j=k+1}^{k+d\max} \phi_{2t} LABPR_{t-j} \qquad ----(7)$$

$$LABPR_t = \lambda_0 + \sum_{i-1}^{k} \lambda_{1i} EPC_{t-i} + \sum_{j=k+1}^{k+d\max} \lambda_{2j} EPC_{t-j} + \sum_{i=1}^{k} \pi_{1i} GDPPC_{t-i} + \sum_{j=k+1}^{k+d\max} \pi_{2j} GDPPC_{t-j} + \sum_{i=1}^{k} \theta_{1i} GCF_{t-i}$$
$$+ \sum_{j=k+1}^{k+d\max} \theta_{2j} GCF_{t-j} + \sum_{i=1}^{k} \psi_{1i} LABPR_{t-i} + \sum_{j=k+1}^{k+d\max} \psi_{2t} LABPR_{t-j} \qquad ----(10)$$

Where, K in the above equations is the optimal lag length determined by SIC and AIC (2 in our own case).

d_{max} is the maximum order of integration of the variables of the model (one in our own case).

In equation seven for instance, Toda-Yamamoto Causality test involves the following decisions among others:

GDPPC is said to Granger- cause EPC if $\beta_{1i} \neq 0$, otherwise it does not.

GCF is said to Granger-cause EPC if $\delta_{1i} \neq 0$, otherwise it does not.

LABPR is said to Granger-cause EPC if $\phi_{1i} \neq 0$, otherwise it does not.

$$EPC_t = \pi_0 + \pi_1 GDPPC_t + \pi_2 GCF_t + \pi_3 LABPR_t + \mu_t \qquad ---(11)$$

All data for the study range from 1990 to 2015 and data span were determined due to data availability. All data were extracted from the World Bank data (2020). Data for gross capital formation for Congo Democratic were forecasted from 1990 to 1993 using the non-linear regression.

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Results and Discussions

The stationarity tests were conducted using four approaches. That is, Levin and Lin and Chu t, ImPesaran and Shin W-Stat, ADF Fisher Chi Square and Phillip Perron chi square. In most cases there are general consensuses on results. Generally, all variables of the models are integrated of order one at one percent significant level.

Table 1: Panel stationarity results

	Test Results at Levels				**Test Results at First Difference**				
Variable	Levin, Lin & Chu t*	Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square	PP - Fisher Chi-square	Levin, Lin & Chu t*	Im, Pesaran and Shin W-stat	ADF - Fisher Chi-square	PP - Fisher Chi-square	Order of integration
EPC	2.31147 (0.9896)	3.61628 (0.9999)	8.97058 (0.9604)	9.10255 (0.9573)	-5.9212 (0.0000)	-6.5417 (0.0000)	76.3333 (0.0000)	158.620 (0.0000)	I(1)
GCF	10.5106 (1.0000)	11.1938 (1.0000)	0.07699 (1.0000)	0.12945 (1.0000)	-1.23644 (0.1081)	-2.86078 (0.0021)	46.6848 (0.0002)	121.017 (0.0000)	I(1)
GDPPC	5.47041 (1.0000)	6.56093 (1.0000)	0.75956 (1.0000)	1.48709 (1.0000)	-5.23616 (0.0000)	-5.57072 (0.0000)	65.3361 (0.0000)	145.673 (0.0000)	I(1)
LABPR	-0.00051 (0.4998)	2.13360 (0.9836)	11.5611 (0.8691)	4.89398 (0.9990)	-1.75056 (0.0400)		31.9567 (0.0222)	34.8558 (0.0099)	I(1)

The study utilized the Pedroni panel cointegration test in testing for the cointegration of our regression model in equation eleven based also on the null hypothesis of no cointegration. To conduct this test and evaluate our results, eleven statistics were estimated and evaluated. The null hypothesis of no cointegration was rejected by seven of the eleven statistics employed at 0.05 level of significance. Therefore, we conclude that Y_t and X_t are cointegrated and; Y_t and X_t are vectors of variables.

Table 2: Pedroni residual cointegration results for model 2
Pedroni Residual Cointegration Test
Series: EPC GDPPC LABPR GCF
Date: 09/10/20 Time: 02:57
Sample: 1990 2014
Included observations: 225
Cross-sections included: 9
Null Hypothesis: No cointegration
Trend assumption: No deterministic trend
Automatic lag length selection based on SIC with a max lag of 4
Newey-West automatic bandwidth selection and Bartlett kernel

Alternative hypothesis: common AR coefs. (within-dimension)

	Statistic	Prob.	Weighted Statistic	Prob.
Panel v-Statistic	0.552824	0.2902	0.457601	0.3236
Panel rho-Statistic	-1.961276**	0.0249	-1.184990	0.1180
Panel PP-Statistic	-5.470324*	0.0000	-3.810785*	0.0001
Panel ADF-Statistic	-5.567094*	0.0000	-3.903436*	0.0000

Alternative hypothesis: individual AR coefs. (between-dimension)

	Statistic	Prob.
Group rho-Statistic	-0.013740	0.4945
Group PP-Statistic	-3.841326*	0.0001
Group ADF-Statistic	-3.791810*	0.0001

Note: *** means p≤ 0.1, ** means p ≤ 0.05, * means ≤ 0.01.

Source: Author's computation (2020)

The Granger causality results based on Toda-Yamamoto is presented in table three below. The results indicated that energy consumption per capita Granger causes labour in West Africa. Gross capital formation, a proxy for capital Granger causes economic growth at one percent significance level. The study also found causality existing between energy consumption and economic growth. Causality runs from economic growth proxy by Gross Domestic Product per capita (GDPPC) to energy consumption per capita. This means that economic growth Granger causes energy consumption. This finding is a validation of the conservation hypothesis. This result is in agreement with the findings of Twerefou, Iddrisu and Twum (2018) and; Quedraogo (2013). See also the other Causality results in the appendix; they have similar results with that of Toda-Yamamoto.

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Table 3: Toda-Yamamoto Results
VAR Granger Causality/Block Exogeneity Wald Tests
Date: 09/18/20 Time: 11:09
Sample: 1990 2014
Included observations: 198

Excluded	Chi-sq	Df	Prob.
Dependent variable: EPC			
GDPPC	5.263753***	2	0.0719
LABPR	0.217359	2	0.8970
GCF	0.303237	2	0.8593
All		4	---
Dependent variable: GDPPC			
EPC	2.000226	2	0.3678
LABPR	0.226316	2	0.8930
GCF	11.70445*	2	0.0029
All		4	---
Dependent variable: LABPR			
EPC	11.45528*	2	0.0033
GDPPC	0.083110	2	0.9593
GCF	0.141237	2	0.9318
All		4	---
Dependent variable: GCF			
EPC	3.745289	2	0.1537
GDPPC	0.311981	2	0.8556
LABPR	0.416113	2	0.8122
All	4.266251	6	0.6407

Test statistics not available for lag coefficients with restrictions
Note: *** means p≤ 0.1, ** means p ≤ 0.05, * means ≤ 0.01.

Source: Author's computation (2020)

Based on the above result which confirms causality running from growth to energy consumption, this study therefore formulated its econometric model in which the dependent variable is energy consumption and economic growth is one of the

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independent variables. We shall interpret the results hereunder given in table two below.

Table 4: Results of the model using different estimation techniques

Dependent variable is EPC			
Independent Variables	Panel Least Squares	Panel Fully Modified Least Squares (FMOLS)	Panel Dynamic Least Squares (DOLS)
Constant	39.93845(1.003738) (0.3166)	_	_
GDPPC	0.046896(5.488673)* (0.0000)	0.031062(3.913437)* (0.0001)	0.026987(2.769994)* (0.0066)
GCF	-9.03E-10(-2.212675)** (0.0279)	-2.31E-10(-0.469665) (0.6391)	4.23E-10(0.568730) (0.5708)
LABPR	1.131131(2.083122)** (0.0384)	-5.205238(-3.375922)* (0.0009)	-4.23811(-2.0789)** (0.0401)
R-Squared	0.131298	0.874563	0.967764
Adj. R-Squared	0.119505	0.867800	0.939518
Fstatistic (Probability)	11.13415(0.000001)*		
DW	0.068459		
Long-run vance	_	1568.914	181.3663
Cross-sections included	9	9	9
N	225	216	198

Note: *** means p≤ 0.1, ** means p ≤ 0.05, * means ≤ 0.01. T-Statistics and respective probabilities are in parentheses.

Source: Author's computation (2020)

The results in table four above indicated that economic growth, labor as well as capital significantly explain energy demand in West Africa. The coefficient of determination which is very low as well as the value of Durbin Watson showed the glaring problem of the Least Squares estimates. There is surely the presence of at least first order serial correlation. The Panel Fully Modified Least Squares (FMOLS) is expected to perform better in this case.

The Panel Fully Modified Least Squares (FMOLS) has a coefficient of determination of about 87 percent and an adjusted coefficient of determination of about 87 percent as well which is a good enough fit. In addition, the explanatory variables of the model nearly conformed with the a priori expectation except capital proxy by gross capital formation (GCF) which negatively relates to energy consumption. Economic growth and labor significantly contributed to the explanation of energy consumption in West Africa. The long run variance of the FMOLS however is high and the coefficient of determination is lower compared with the Dynamic Least Squares (DOLS), we now interpret our DOLS estimates.

The long-run variance of the DOLS is relatively small and it is 181.3663. The coefficient of determination of about 97 percent indicates that about ninety seven percent of the variability of energy consumption is captured by the independent variables of the model. The adjusted coefficient of determination is about 94 percent. All the explanatory variables of the model conformed with the apriori expectations.

There is a direct relationship between Gross Capital formation (which is a proxy for capital) and energy consumption. The level of relatedness is very low and insignificant.

Labor (LABPR) is inversely related to energy consumption. The more of labor utilized in a developing economy as against man-made capital, the less of energy that will be consumed. The above is true because most African economies are agrarian and practiced rudimentary/peasant farming as against the highly mechanized agriculture of the western World. By virtue of the above, there would be a decline in energy consumed as more labor is utilized in the region.

The main variables of the study are: Energy consumption (EPC) and Per Capita Gross Domestic Product (GDPPC) are positively related. The result shows that economic growth significantly explains energy consumption in West Africa. A dollar increase in Per Capita GDP other things being constant will cause energy consumption to increase by 0.03 US dollar. This result is in further support of the conservation hypothesis. This result is in tandem with those of Sahoo and Sethi (2020), Tariq et. al. (2018).

Conclusion and Recommendation

Energy is a major input that is utilized in all production processes and it is an important input consumed as an output for increasing people's welfare. It is widely viewed as a major determinant of economic and social development. Yet there are those that belong to the neutrality school that assumed that energy consumption has very minor role to play in the issue of economic growth (Solow, 1974). This study therefore investigated the validity of any of the four hypotheses (conservation, growth, feedback and neutrality) in West Africa with a view to making good policy intervention that may propel economic growth in West Africa. This study therefore applied stationarity tests and Pedronicointegration as well as causality tests (Granger-Causality, Vector Autoregressive (VAR) Causality and Toda-Yamamoto Causality) and regression analysis (Ordinary Least Squares (OLS), Panel Fully Modified Least Squares (FMOLS) and Dynamic Least Squares (DOLS)) in accomplishing the investigation. The study found per capita GDP to Granger cause energy consumption in West Africa and the Causality runs from GDP per capita to energy consumption. Energy consumption (EPC) and Per Capita Gross Domestic Product (GDPPC) are positively related. The result shows that economic growth significantly explains energy consumption in West Africa. A dollar increase in Per Capita GDP other things being constant will cause energy consumption to increase by 0.03 US dollar. Based on the above therefore, since economic growth implies more energy consumption, and at present, energy consumption in West Africa is predominantly fossil-based which is unsustainable as it is non-renewable. West African governments must work to encourage more energy efficient production processes. In addition to this, government must put up policies to generate and utilize more renewable energy sources. This will reduce the pollution associated with fossil-based energy sources.

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APPENDIX

Appendix 1: VAR No - Causality Results

VAR Granger Causality/Block Exogeneity Wald Tests
Date: 09/18/20 Time: 10:28
Sample: 1990 2014
Included observations: 207

Dependent variable: EPC

Excluded	Chi-sq	df	Prob.
GDPPC	9.689866*	2	0.0079
GCF	1.862250	2	0.3941
LABPR	0.386235	2	0.8244
All		4	---

Dependent variable: GDPPC

Excluded	Chi-sq	df	Prob.
EPC	0.641846	2	0.7255
GCF	6.960702**	2	0.0308
LABPR	0.032749	2	0.9838
All		4	---

Dependent variable: GCF

Excluded	Chi-sq	df	Prob.
EPC	1.523222	2	0.4669
GDPPC	0.179143	2	0.9143
LABPR	0.107217	2	0.9478
All	2.465375	6	0.8723

Dependent variable: LABPR

Excluded	Chi-sq	df	Prob.
EPC	2.347573	2	0.3092
GDPPC	0.340296	2	0.8435
GCF	0.716823	2	0.6988
All		4	---

Test statistics not available for lag coefficients with restrictions
Note: *** means p≤ 0.1, ** means p ≤ 0.05, * means ≤ 0.01.
Source: Author's computation (2020)

Appendix 2: Granger Causality Results

Pairwise Granger Causality Tests
Date: 09/10/20 Time: 03:04
Sample: 1990 2014
Lags: 4

Null Hypothesis:	Obs	F-Statistic	Prob.
GDPPC does not Granger Cause EPC	189	2.70246**	0.0320
EPC does not Granger Cause GDPPC		0.41012	0.8012
GCF does not Granger Cause EPC	189	0.22502	0.9242
EPC does not Granger Cause GCF		1.08897	0.3635
LABPR does not Granger Cause EPC	189	0.36448	0.8337
EPC does not Granger Cause LABPR		2.77104**	0.0287
GCF does not Granger Cause GDPPC	189	5.03731*	0.0007
GDPPC does not Granger Cause GCF		0.13206	0.9705
LABPR does not Granger Cause GDPPC	189	0.71062	0.5857
GDPPC does not Granger Cause LABPR		0.21895	0.9276
LABPR does not Granger Cause GCF	189	0.27478	0.8940
GCF does not Granger Cause LABPR		0.87462	0.4803

Note: *** means p≤ 0.1, ** means p ≤ 0.05, * means ≤ 0.01
Source: Author’s computation (2020)