

ELECTRICITY CONSUMPTION AND ECONOMIC GROWTH NEXUS: EVIDENCE FROM 21 AFRICAN COUNTRIES

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ABSTRACT

This study examined the impact of electricity consumption on economic growth in 21 African countries. Prior to the estimation of the model, the study conducted a preliminary review of the nature of the data using descriptive statistics. The panel unit root tests using the Levin, Lin and Chu test; Augmented Dickey Fuller test; and the Im, Pesaran, and Shin test were also conducted. Thereafter, the long run relationship between the variables was examined after optimally selecting the order lag. This panel cointegration test was done using the Residual-Nased DF and Augmented Dickey Fuller tests also known as the Kao test, Perodni cointegration test and the Johansen Fisher cointegration test. The Toda Yamamoto causality analysis was also conducted to ascertain the direction of causality between the variables. The findings of this study showed a stable long-run relationship between electricity consumption and economic. In line with the Growth hypothesis electricity consumption granger causes economic growth in African countries. However, the consumption of electricity was not granger caused by economic growth. Governments are enjoined to join forces with the private sector for the development of electricity infrastructure in order to boost its consumption and consequently, economic growth

Key words: Economic Growth, Electricity Consumption, Toda Yamamoto causality test, Panel cointegration.

1 Introduction

The critical role being played by the energy sector in the development of the economy is not in doubt (Hall & Klitgaard, 2012). Apart from capital and labour, Obange, Mukras & Siringi (2013) considers energy as a critical factor of global economic production. In the opinion of Stern (2010), scarcity of energy inflicts a strong restriction on economic growth. However the effect of energy surplus on the economy is however much reduced.

The nature of technological change and obtainability of energy have been observed by Stern (2011) to determine the role of energy either as an enabler of or a constraint to the growth of the economy. For Stern, and Kander (2012), output growth is strongly constrained when the substitutability between a labour-capital aggregate and energy is inelastic. The resultant scarcity of energy causes a low income steady-state. In the reverse, abundant energy services serves as an engine of growth

limited only by the Solow model prescription. With respect to the developing countries, UNIDO (2011) ascribed the lack of development to the dearth of energy. This deficiency also accounts for the poor execution of the Millennium Development Goals in the areas of productivity, health, communication services, potable water and education.

Stylised facts suggest positive, and bi-directional relationship between electricity energy and economic growth. Such facts include the high dependence of economic growth on energy and the promotion of advanced energy technology in addition to wide-spread utilization of energy resources by a growing economy (Karanfil, 2009 and Payne, 2009). The direction of causality is also important to policy makers in order for them to proffer appropriate policy on energy generation and conservation. When causality runs from economic growth to energy consumption or if there is no causality in either direction this denotes a less energy-dependent economy and, energy conservation policies may be implemented with little or no adverse effects on economic growth.

Several methods have been deployed including the two-regime threshold co-integration models (Sa'ad, 2010, Yu & Jin, 1992), autoregressive distributed lags bounds test (Pesaran, Smith Shin, 2001), bi-variate Vector Auto-regressive model (Nwosa & Akinbobola, 2012), panel data approach (Apergis & Danuletiu, 2012, Ozturk, Aslan, & Kalyoncu, 2010) and Granger causality test (Kaplan, Ozturk, & Kalyoncu, 2011). Some studies have also deployed multivariate models including variables such as real gross fixed capital formation, labour force, carbon dioxide emissions, population, exchange rates and interest rates.

There have been fewer studies on African countries compared with papers on developed and emerging nations. However, some efforts

have been expended in this regards on African countries (Akinlo, 2009; Bildirici, 2012 Esso, 2010; Squalli, 2007; Eggoh, Bangaké, & Rault, 2011; Odhiambo, 2009, 2010). The inconsistent findings in the literature constitute a challenge in policy formulation for fast and efficient economic growth.

The need for further clarity on the relationship and the relative paucity of research on this in Africa makes the need for this study manifest. This paper therefore seeks to investigate the underlying links between electricity consumption and the growth of the economy. The innovative contribution of this study is the determination of the long-run relationship between energy consumption and real GDP.

In furtherance of this objective, the remaining part of this study is structured as follows: The next section deals the review of existing literature and the theoretical underpinning of the study. In section three, data and the methodology are presented. In section four, the findings are presented and discussed. Section five concludes and recommends.

2. Literature Review

There is a dual presentation in this section: the summary of selected relevant studies and the review of theories.

2.1 Review of Relevant Literature

The survey of literature reveals that the nexus of energy (electricity) consumption-economic growth causality have yielded conflicting results. The approaches adopted by authors focus on either testing the role of energy (electricity) in engendering economic growth or evaluating the direction of causality between these two variables. Empirical evidence has been sought from developed, emerging and developing countries. The overview of selected studies is presented in Table 1.

**Table 1: Overview of Selected Studies on Energy-GDP Nexus
Empirical Evidence from Developed and Emerging Countries**

Authors	Period	Countries of Study	Objective(s) of the Study	Methodology	Result Findings	Conclusions/ Recommendations
Aslan, A. Aperiş, N. & Yildirim, S. (2014).	1973 Q1-2012 Q1	USA	The research investigates the dynamic relationship between energy usage and the growth of the economy.	Wavelet transformation causality test	Energy → Growth Energy ↔ Growth One-way causality finer time scales. Two-way causality at coarser scales At intermediate and long-run scales	Power infrastructural development should be sustained into the long term
Yu, E. and Choi, J. (1985)	1954-1976	US, UK, Poland Korea, Philippines	The aim of the study is to expand the investigation of Yu and Hwang (1984) from an international perspective and disaggregated energy source.	Granger Causality test	Energy → Growth There exists a bi-directional causal connection among the consumption of energy and the growth of the economy	Energy policies should take the differences in the linkages between energy utilization and economic growth in to consideration for achieve sustainable economic growth.
Authors	Period	Countries of Study	Objective(s) of the Study	Methodology	Result Findings	Conclusions/ Recommendations
Stern, D. I. (2010)	1948-1994	USA	The research reviews the connection between the growth of the economy and the use of energy in production.	Granger Causality and cointegration tests	Growth – Energy Uni-directional relationship exists between the growth of the economy in the direction of the use of energy	Consideration should be given to Environmental matters when formulating energy policies
Narayan, P. K. and Smyth, R. (2008)	1974-2002	G7 Countries	The objective of the study is to investigate the two-way link among growth of the economy and energy usage	Vector Error Correction Model (VECM)	Energy → Growth One-way directional relationship. Policies aimed at saving energy have the dimmer influence on the negative component of energy consumption and the boosting impact on the positive elements of energy consumption.	Policies designed to save energy should be forcefully focused on so as to achieve the objective sustainable and high levels of economic growth.
Soytas, E. and Sari, R. (2003)	1950-1990	UK, Argentina, Turkey, Canada South Korea, & USA.	The aim of the study is to investigate the time series properties of energy consumption and GDP and re-examines the causality relationship between the two series in the top 10	Bivariate Vector Error Correction Model (VECM)	Growth ↔ Energy Growth → Energy Energy → Growth The study find bi-directional causality in Argentina, Korea and Italy. Causality moved to GDP from energy consumption. One-way causality to GDP in Japan,	Conservation policies on energy should not be deployed in Japan, Germany, France and Turkey since this is deleterious to economic growth

			emerging markets G-7 countries.		Turkey, Germany and France. There is reversed causality relationship in Korea and Italy.	
Shiu, A. & Lam, P.L. (2004)	1971- 2000	China	To investigate the direction of causality between the usage of electricity and the growth of the economy in China.	Cointegration & Error Correction Model (ECM)	Energy→ Growth. The findings of the study is consistent with Growth-Led- Energy Hypothesis.	Policy measures should be directed at enhancing the power infrastructure in order to engender economic growth
Fatai, K. Oxley, L & Scrimgeour , F.G. (2002)	1960- 1999	New Zealand	Aim of the study is to compare the impact of energy conservation policies in New Zealand and Australia and several Asian economies.	Granger Causality test	Energy-Growth Energy conservation policies have no significant effect on real GDP growth in Australia and New Zealand. Reverse situation obtains poor Asian countries.	The study recommends that the agricultural sector which is energy intensive in New Zealand be analyzed further.

Empirical Evidence from Developing Countries

Authors	Period	Countries of Study	Objective(s) of the Study	Methodology	Result Findings	Conclusions / Recommendations
Helmi H., Sbia, R. Hakimi, A. & Boukef-Jlassi, N. (2014)	1970- 2009	Brazil, India, Indonesia, China and South Africa	The objective set by the study was to check for the possible affiliation if any amid electricity consumption per capita and GDP per capita.	Granger causality tests Panel Cointegration analysis	Energy↔ Growth Cointegration of GDP and electricity usage was confirmed. Long- run Granger causality tests indicate a linkage between GDP electricity usage and economic growth was confirmed except for South Africa.	Government should pursue green energy programme (solar, biomass and hydro) Government enjoined to provide electricity to the rural areas.
Altinay, G. & Karagol, E. (2005)	1950- 2000	Turkey		Dolado- Lütkepohl test. Granger causality test	Energy→ Growth The finding reveals strong evidence of one-way causality moving from the electricity usage to national income in Turkey.	The government should provide the necessary fillip required for the development of the electricity sector
Kaplan, M., Ozturk, I & Kalyoncu, H. (2011)	1971- 2006	Turkey	The aim of the study was to examine the impact of energy usage on the Turkish economic growth.	Vector Error Correction Model (VECM) Granger causality test	Growth↔ Energy The results reveal bi-directional causality between energy usage level and the growth of the economy. Both variables are cointegrated.	Government should support the development of energy resources.

Apergis & Payne (2009)	1980-2005	11 countries of the CIS	The study was conducted in order to determine the possible nexus between the consumption of energy and economic growth.	Pedroni's heterogeneous panel cointegration test Granger causality test	Growth $\leftrightarrow$ Energy There is a long-run equilibrium connection among labor force, real GDP, energy usage and real gross fixed capital formation. The Granger causality test is supportive of the Energy-led growth hypothesis.	Government is requested to factor in environmental concerns in the quest for sustainable through the use of energy-efficient resources.
Souhila, C. & Kourbali, D. (2012)	1965-2008	Algeria	The nexus between the consumption of energy and the economic growth in Algeria is the focus of investigation of this study.	Vector Error Correction Model (VECM) Granger Causality Test	Growth $\rightarrow$ Energy No long run cointegration was found between the two variables but there exists a one-way causality moving from GDP to the usage level of energy, but not vice versa.	The government can deploy policies aimed at conserving energy policies that aim at curtailing energy use for environmental friendly development purposes.
Apergis, N. and Danuletiu, D. (2012)	2000-2011	Romania	The research investigates the possible nexus amid the level of usage of energy and the growth of the Romanian economy.	Panel Cointegration and VECM Granger causality test	Energy $\rightarrow$ Growth The study finds long-run connection amongst real gross fixed capital formation, real GDP, energy consumption, and the labour force. The causality test specifies movement only from the consumption of energy to economic growth.	The government is required to further develop the energy infrastructure in order to achieve long term economic development.
Bildirici, M.E. (2013).	1970-2010	Zambia, Cameroon, Senegal, Ghana, Cote D'Ivoire, Togo, Gabon, Guatemala, Congo, Ethiopia, and Kenya	The intention of the research is to scrutinize the link between electricity usage and the growth of the economy.	Autoregressive Distributed Lag (ARDL) Bounds cointegration test Granger Causality test	electricity $\rightarrow$ Growth The test results show that variables are cointegrated in all the countries except Guatemala which served as the control nation. The result of the causality test supports the conservation hypothesis in Zambia and Senegal. It however is in congruence with the energy-led growth hypothesis in Mozambique, Kenya, Congo Rep., Cameroon, and Ethiopia.	The energy policies on take the differences in the linkages between energy consumption and economic growth in to consideration in order to achieve sustainable economic growth.
Obange, N, Mukras, M.S.,	1970-2010	Kenya	The objective of the study is to	Cointegration Granger	Since the country depends largely on	The manufacturing companies are

& Siringi, E.M. (2013).			investigate the effect of disaggregated energy usage (petroleum and electricity) on the growth of the manufacturing sector in Kenya.	Causality & VECM	petroleum and given the high price volatility, this energy source significantly and adversely affect the cost and prices of manufactured products.	enjoined to migrate more to the use of hydro-energy based technologies.
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Authors	Period	Countries of Study	Objective(s) of the Study	Methodology	Result Findings	Conclusions / Recommendations
Nwosa, P. I. & Akinbobola, T.O. (2012).	1980 - 2010	Nigeria	The aim of this research was to test the link between the aggregate energy consumption and the sectoral output in Nigeria	Bi-variate Vector Auto-regressive (VAR)	Agricultural and manufacturing ↔ Energy Manufacturing output → Energy A two-way linkage between agricultural and manufacturing outputs on the one hand, and the aggregate energy consumption on the other was reported. The relationship with the service output was found to be unidirectional in the direction of aggregate energy consumption.	The one fit-for-all energy policy is recommended in preference to policies that are sector-specific
Kemisola O., Damilola, O. & Olawumi, A. O (2014)	1980-2012	Nigeria	The objective of the study is to evaluate the estimates the nexus between energy utilization and GDP.	Vector Auto Regressive (VAR) Error Correction Model (ECM)	Growth → Energy Positive nexus between the consumption of energy resources and the growth of the economy.	Need for energy resources diversification with emphasis on renewable power options.
Dudzevičiūtė, G. & Tamošiūnienė R. (2014).	1995-2012	Lithuania, Latvia and Estonia	The study's objective is to examine the causal association between the utilization of energy resources and economic growth in the Baltic countries.	Granger causality test	Growth → Energy Growth – Energy There is a significant and strong affiliation in Latvia, moderate and significant relationship in Estonia, and an insignificant connection between energy consumption and economic growth in Lithuania.	Different national energy policies is required by each country to address its economic growth

Source: Authors' compilations

Note: ↔ means bi-directional causality exists between the variables

→ means that causality flows from one variable to the other.

– means no causality exists between the variables.

The broad-spectrum observation from these studies as presented in Table 1 reveal conflicting results.

With specific respect to Africa, the results are not unanimous. The following examples will suffice: The use of ARDL method by Wolde-Rufael, (2005) in testing the long run relationship between energy consumption and GDP for 19 African countries between 1971 and 2001 confirmed causality running from energy consumption to GDP. This is in congruence with similar analysis by Odhiambo (2010) who evaluated the causal connection between economic growth and the consumption of electricity energy in three African countries, found causality from energy to economic growth direction. The study of 18 Sub Saharan African countries by Basiru (2014) between 1980 and 2011 using the panel unit root test and panel co-integration reports electricity consumption propels economic growth in the southern and eastern parts of Africa. However there is the absence of causality between the two variables in the other parts of the continent.

Other works includes the research by Esso, (2010) who applied the cointegration technique for some countries in Africa (Cameroon, Nigeria, Kenya, South Africa) between 1970 and 2007 found no relationship between the variables. For Bildirici, (2012) who applied the MS-Granger causality approach in nine African countries, found bi-directional causative linkage between the consumption of electricity and real GDP. The long-run connection between the use of energy per capita and real GDP per capita was investigated Wolde-Rufael (2006) in 19 African countries, for the period 1971 to 2001. The investigation deployed the Bounds co-integration and the Vector Auto Regressions techniques revealed long run association between the variables in eighty percent of the countries.

In summary, no unanimous conclusion can be drawn on the existence and the direction of causality between the consumption of electricity and the growth of the economy either in the short or the long run. The next discussion is on the theoretical underpinning of the study.

2.2 Theoretical Review

Researches on the causal relationships between economic growth and energy consumption are usually grouped into four testable hypotheses. These are the Neutrality hypothesis, Feedback hypothesis, Conservation hypothesis and the Growth hypothesis. This will be discussed briefly in turns.

Neutrality hypothesis as identified by Asafu-Adaye, 2000; Jumbe, 2004) provides that there is no causality between economic growth and energy (electricity) consumption. Governmental policies aimed at generating energy production and its consumption does not significantly promote economic growth. Alternative energy conservation efforts also fail to retard economic growth (George and Nickoloas, 2011; Ezatolloh, Nazari, and Nasrindoost, 2010).

With the Feedback hypothesis, the consumption of energy and the growth of the economy are taken to complement one another. There is a bi-directional causal relationship between economic growth and energy consumption which reflects the interdependence between both variables. In this case, a surge in the consumption of energy kindles the growth of the economy. The reverse causes the economy to decline. In effect, Hou, 2009; Omotor, 2008 and Shahbaz and Lean (2012) suggest a bi-directional relationship between the consumption of electricity energy and economic growth.

The Conservation hypothesis suggests that there is little or no impact of the deployment of energy conservation policies on the growth

of the economy. It ascribes a uni-directional causality from economic growth to the consumption of electricity energy. The proposition of Mehrara (2007) therefore is that deploying policies aimed at energy conservation, may not have deleterious impact on the growth of the economy. The conservative hypothesis holds if a rise in real GDP results in an increase in energy consumption

The Energy-led Growth Hypothesis (Kraft & Kraft, 1978) is the contra directional theory of the Conservation hypothesis. The growth hypothesis, suggests that energy consumption plays a critical function role in economic growth. Indeed, energy consumption is considered to be a pre-condition for economic growth (Kasperowicz, 2014). Given these four perspectives in mind, the computational methodology and procedures will be presented in the next section

3. Methodology

This study investigates the connection between the consumption of electricity (EC) and real GDP (Y) by using three approaches. First, we carried out a Panel unit root tests using Im, Pesaran and Shin Test; Levin, Lin and Chu Test; and ADF Fisher Chi Square. The second step is the conduct of Panel cointegration test using the ADF Tests (Kao

Tests) Residual-Nased DF, Johansen Fisher Cointegration Test and Perodni Cointegration Test. In the third stage, the Toda and Yamamoto test is conducted to establish the direction of causality between the variables. The choice of the twenty-one (21) African countries covering period of 1980-2013 was based on the availability of data.

3.1. Source of Data and Description of Variables

The sample covers the period of 1980-2013 for 21 African countries. All data are obtained from the World Development Indicators (2015) database. Electricity consumption is energy use in kilo watts. The real GDP is obtained by converting the local currency values to the United States Dollars by applying the Purchasing Power Parity rates of each country. All variables are in logarithm form.

3.2 Model Specification

The test for the existence of a long-run cointegration among electricity consumption and the independent variables using panel cointegration tests suggested by Pedroni (1999 and 2004). The usage of estimated residual is suggested by Pedroni, from the hypothesized long-run regression in the following equation:

$$y_{i,t} = \alpha_i + \delta_i t + \beta_{1i} x_{1i,t} + \beta_{2i} x_{2i,t} + \dots + \beta_{Mi} x_{Mi,t} + e_{i,t} \quad (2)$$

for $t = 1, \dots, T$; $i = 1, \dots, N$; $m = 1, \dots, M$,

Where:

T = number of observations

N = number of cross-sectional units in the panel

M = number of regressors.

α_i = specific member intercept (fixed effects parameter)

$\delta_i t$ = slope of the coefficients and specific member time effects

The study in effect, deploys the long-run association between the consumption of electricity energy and Real GDP by using equation (3):

$$\log EC_{it} + \beta_i \log RGDP_{it} + \varepsilon_{it} \quad (3)$$

Where:

EC = Energy consumption

$RGDP$ = Real Gross Domestic Product

i = the country,

t = the time,

α_i = the fixed country effect and

ε_{it} = the white noise stochastic disturbance term.

θ_i = the elasticity of electricity energy consumption of Real Gross Domestic Product.

3.3 Estimation Procedure

The procedure consists of three steps in line with the approach adopted by Basiru (2014). The first step is the conduct of panel unit root tests, the second is the panel cointegration test and the third is the Toda Yamamoto causality analysis.

Step 1: Panel unit root tests

There are several panel data unit root tests based on the AR(1) process. Im, Pesaran and Shin (2003), Maddala and Wu (1999), Levin, Lin and Chu (2002), and Choi (2001) lend themselves to veritable use. These tests are formulated generally in the form of:

$$\alpha_{it} = \delta_i + \beta_{it} + \theta_i \gamma_{it-1} + \mu_{it} \quad (4)$$

Where:

β_i = the individual trend

T = the number of periods ($t = 1, \dots$)

δ_i = the country specific fixed effect,

N = the number of countries ($i = 1, \dots$)

μ_{it} = the error term.

θ_i = an autoregressive coefficient.

The test of the presence of a unit root in γ_{it} is if $|\theta_i|$ is equal to unity. Note that Panel unit root tests are generally classified into two depending on the assumptions regarding whether the status of θ_i (constant or fluctuating).

Step 2: Panel cointegration test

The second step is to examine the possibility of the subsistence of a long run relationship between the variables. Prior to this, the optimal order lag will have to be determined given the sensitivity of cointegration test to the choice of lag length. The sequential modified LR test statistic (each test at 5% level), Final prediction error (FPE), Akaike information criterion (AIC), Schwarz information criterion (SC) and Hannan-Quinn information criterion (HQ) will be utilized.

The co-integration test propounded by Pedroni (1999) employ seven test approaches: Panel v -statistics, Panel ρ -statistics, Panel PP-statistics, Panel ADF-statistics, Group ρ -statistics, Group PP-statistics and Group ADF-statistics. The second-generation cointegration tests, for instance Westerlund (2007), is not feasible given our dataset. The study also considered other conventional panel cointegration tests to include Kao Residual Cointegration test and Johansen Fisher Cointegration Test.

Step 3: Toda and Yamamoto Causality TYC)

The third step is the estimation of the Toda and Yamamoto (1995) Causality test in order to determine the direction if any, of the causality between the two variables. The choice of the TYC is predicated on the fact that the variables are cointegrated but non-stationary, a situation that would have made the result from Granger causal inference invalid (Toda & Yamamoto, 1995; and Dolado & Lutkepohl, 1996). This procedure is superior to ordinary Granger - causality tests. This is because there is no need to pre-test for the cointegrating properties of the system.

It in effect obviates the possible attendant bias linked with both cointegration and unit roots tests. Therefore the technique can be deployed notwithstanding the fact that the variables are stationary at level I (0), integrated at the first difference I (1), or even if the series are not cointegrated or indeed if they are cointegrated of an arbitrary order.

In line with the method recommended by Toda and Yamamoto the VAR (p) systems that are asymptotically X^2 distributed to employ Wald tests for k linear restrictions. The VAR (p) is formatted thus:

$$X = C_0 + \sum_{j=1}^{k+d} X_{t-j} + \sum_{j=1}^{k+d} Y_{t-j} + u_i + v_t + \varepsilon_{xt} \quad (5)$$

$$Y = C_0 + \sum_{j=1}^{k+d} Y_{t-j} + \sum_{j=1}^{k+d} X_{t-j} + u_i + v_t + \varepsilon_{yt} \quad (6)$$

Where:

X = Log EC

Y = Log RGDP

u_1 = individual country specific effects

v_t = common time effects

Prior to estimation using TYC approach, the d_{max} which is the maximum integration order of the variables to be utilised in the model will be assessed. The unit root test (Augmented Dickey Fuller) is deployed for this purpose. The following optimal lags selection criteria are in use: Schwarz Info Criterion (SIC), Bayesian information criterion (BIC) or the Akaike Information criterion (AIC). Sometimes, a democracy of these techniques is deployed which ever makes the VAR well behaved in term of AR unit root graph, VAR residual serial correlation LM-stat, VAR residual normality tests.

4. Empirical Results

4.1 Panel Unit Root Test Results

The panel unit root test was conducted for the variables at level with individual effect as well as with individual effect and trend. The tests were also performed on the variables at first difference considering both individual effect and time trend. All the selected countries were also tested. The results which show that the variables are non-stationary in their level form both with individual effects and individual effects and trend term are presented in Table 3.

Table 3: Panel Unit Root Test (at level)

Test	At level (individual effect)		First difference (individual effect)		Order of Integration
	ECPK	GDPK	ECPK	GDPK	
LLC	5.88(1.00)	7.58(1.00)	-3.10*(0.00)	-9.04*(0.00)	<i>I</i> (1)
IPS	7.45(1.00)	8.26(1.00)	-10.40*(0.00)	-10.22*(0.00)	<i>I</i> (1)
ADF	6.75(1.00)	7.88(1.00)	-9.90*(0.00)	-9.95*(0.00)	<i>I</i> (1)
	At level (individual effect with trend)		First difference (individual effect with trend)		
LLC	4.02(1.00)	2.59(0.99)	-1.450*(0.00)	-9.04*(0.00)	<i>I</i> (1)
IPS	4.99(1.00)	5.89(1.00)	-10.01*(0.00)	-11.11*(0.00)	<i>I</i> (1)
ADF	4.87(1.00)	6.02(1.00)	-9.17*(0.00)	-10.21*(0.00)	<i>I</i> (1)

Source: Authors' computations using e-views 9

Note: LCC, IPS, ADF and PP implies Levin, Lin and Chu Test; Im, Pesaran and Shin Test; ADF Fisher Chi Square and ADF Choi z-stat Tests respectively. The number in parenthesis represents the probability value, while *, **, and *** represent 1%, 5% and 10% level of significance respectively.

Indeed, the reports in Table 3 shows that the stationary status of the variable is not sensitive to choice of unit root test technique. All three panel unit root tests (Levin, Lin and Chu Test; Im, Pesaran and Shin Test; ADF Fisher Chi Square and ADF Choi z-stat) unanimously identifies the two variables as being stationary at the first difference either with individual effects or with individual effect and trend term. The null hypothesis of no unit root can be rejected for all the variables at level.

The empirical implication of our unit root results is that economic growth and energy consumption has a unit root features. Thus, modeling them in their level form given their stationarity status may result in spurious regressions which indicate a significant relationship between the growth of the

economy and the consumption of electricity energy even when that is not the case. The series required the conduct of cointegration testing. This is presented in the next section.

4.2 Selection of Optimal Lag Order Results

In order to assess the long run convergence of the variables, co-integration tests would have to be conducted. However given the sensitivity of cointegration test to the choice of lag length, a series of nested likelihood ratio tests was conducted in order to determine the optimal lag length (p). The Kao residual-based panel cointegration test, the Johansen-type panel cointegration test, and the Pedroni residual cointegration techniques lend themselves for use as suggested by (Pedroni, 1999). The result is presented in Table 4.

Table 4: Lag Order Selection Criteria

Endogenous variables: GDP per capita, Energy Consumption Included observations: 525					
Lag	LR	FPE	AIC	SIC	HQ
0	NA	1.19E+12	33.48	33.50	33.49
1	223703%	1.66E+10	29.21	29.26*	29.23*
2	1225%	1.65E+10	29.20	29.28	29.23
3	1118%	1.64E+10	29.19	29.31	29.24
4	408%	1.65E+10	29.20	29.35	29.26
5	365%	1.66E+10	29.21	29.39	29.28
6	28.80*	1.60e+10*	29.17*	29.38	29.25
7	180%	1.61E+10	29.18	29.42	29.28
8	426%	1.63E+10	29.19	29.46	29.30

Source: Authors' computations using e-views 9

* indicates lag order selected by the criterion

LR: Sequential Modified Least Likelihood Ratio test statistic (each test at 5% level)

FPE: Final Prediction Error

AIC: Akaike Information Criterion

SC: Schwarz Information Criterion

HQ: Hannan-Quinn Information Criterion

The three methods selected different order lags. Whereas the preferred lag order by the Schwarz information criterion (SIC) and Hannan-Quinn information criterion (HQ) was one, the Final Prediction Error (FPE), Akaike Information Criterion (AIC) on the other hand tended toward lag order six. This study selects the smallest critical value as the lag length based on the SIC and HQ criteria.

4.2. Panel Cointegration Test Results

The result of the estimation of the various panel cointegration tests (the Johansen-type panel cointegration test, Kao residual-based panel cointegration test, and the Pedroni residual cointegration test) are presented in Table 5. Indeed, the weighted statistics of Pedroni Residual Cointegration Test (Panel v-statistics, Panel rho-statistics, Panel PP-statistics and Panel ADF-statistics) are also reported.

Table 5: Panel Cointegration

Panel (a): Kao Residual Cointegration Test		
Test statistics	1.724*	
P value	0.04	
Panel (b): Johansen Fisher Cointegration Test		
Trace test	149.4 (0.00)	
Maximum Eigenvalue	149.4 (0.00)	
Panel (c): Pedroni Residual Cointegration Test		
Null hypothesis of no. cointegration statistics weighted statistics		
Panel v-Statistic	2.58 (0.01)	0.68(0.25)
Panel rho-Statistic	-0.49 (0.31)	-1.33(0.09)
Panel PP-Statistic	-0.61 (0.27)	-2.22(0.01)
Panel ADF-Statistic	-0.78 (0.22)	-2.50(0.01)

Source: Authors' computations using e-views 9

Note: The probability values are in in parentheses

As shown in Table 5 above, the results of the three cointegration tests considered unanimously confirm the absence of cointegrating relationship between the consumption of energy and the growth of the economy. They suggest that the null hypothesis should be rejected. This therefore implies that we can assume a long-run connection between the consumption of energy and the growth of the economy in Africa. That is, even if there are shocks in the short run, which may affect movement in the

variables, they can still converge with time, in the long run.

Stating it differently, the assumption of the absence of long-run connection between economic growth and energy consumption do not empirically hold in the case of Africa. The long run relationship between the variables cointegrating tests however does not possess the capacity to indicate the direction of causality. This is provided by the Toda and Yamamoto (1995) causality test which is the next presentation.

4.3. Toda and Yamamoto Causality

The result of the Toda and Yamamoto (1995) test is presented in Table 6.

Table 6: Toda and Yamamoto Causality Test Result

Wald test statistics (probability Value)			
Variables	Economic Growth	Electricity Consumption	Direction of causality
Economic Growth	-	23.70 (0.00)	Uni-directional relationship electricity → growth
Electricity Consumption	12.07 (0.15)	-	

Source: Authors' computations using e-views 9

Note: The probability values are in in parentheses

Deploying the test, the significance of the p-values of the Wald (WALD) statistics, with maximum lag order of 6 depict the direction of causality to be from energy consumption to economic growth in the selected African countries only. However, no causality exists from the growth of the economy to the consumption of energy. In effect, a uni-directional causation subsists from the consumption of electricity energy to the growth of the economy in Africa.

4.4. Discussions

The findings of this study show that electricity consumption granger causes economic growth in African countries which suggest that energy consumption is one of the drivers of economic growth in Africa. More so, the study established long run relationship between economic growth and energy consumption in

Africa. This implies energy consumption plays a significant role in economic growth for a longer period of time. This means that energy consumption explained the nature of the economic growth experienced in Africa and a decline in the consumption of electricity energy may constraint the growth of the economy. The result of this study is in line with findings of Basiru (2014) for Sub-Saharan Africa, Odhiambo (2010) for South Africa, Apergis and Payne (2009), Soytas and Sari (2003) for Japan, Germany and France.

A cursory review of electricity average consumption per capita between 1990 and 2013, in selected African countries shows that South Africa in the south, Libya, Egypt and Tunisia in the northern part of Africa consumed electricity in excess of 1,000 KWh per capita (Figure 1).

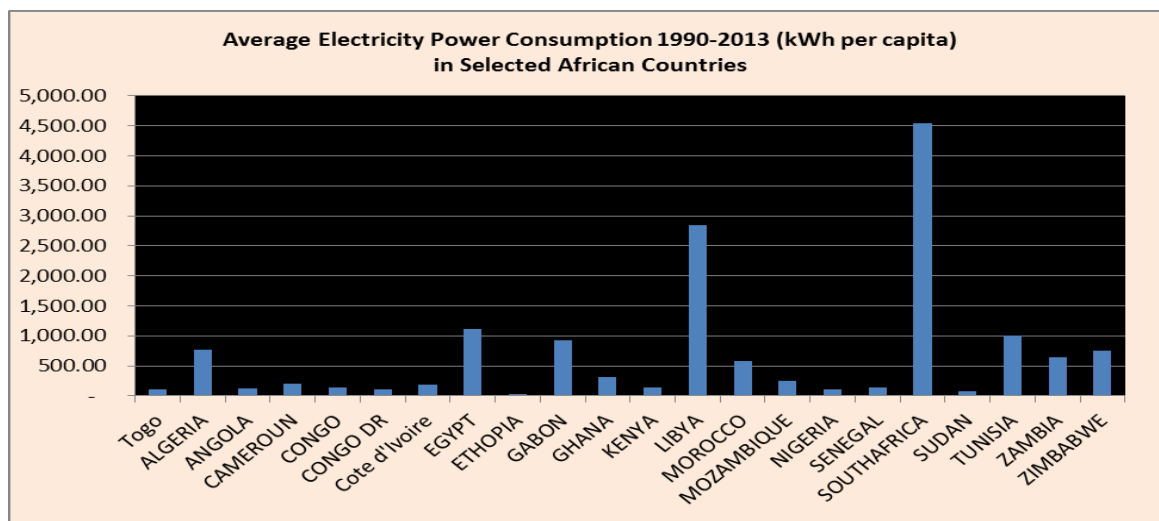


Fig.1 Average Electricity Power Consumption 1990-2013 (kWh per capita) in Selected African Countries
Source: Authors' computation from World Bank (2014).

The four countries accounted for a whopping 63 percent of total consumption in Africa. These four countries however made for only 38 percent of the GDP per capita during the same period (World Bank, 2014).

The finding is also in consonance with the Growth hypothesis suggesting critical and functional role of electricity in the quest for economic growth. Indeed, energy consumption is considered to be a pre-

condition for economic growth. This is so given the fact that energy is both a direct input in the production process and an indirect input that complements labour, capital and entrepreneurship inputs (Odhiambo, 2009; Ebohon, 1996). In effect, it provides for a uni-directional causality moving from the consumption of electricity energy to the growth of the economy (Narayan & Smyth, 2005; Ghosh, 2002). A country experiencing this phenomenon is said to be energy dependent. Therefore, the drop in the consumption electricity energy will cause a slump in the growth of the economy. A negative shock to the consumption of electricity either through, hike in the price of electricity or due to electricity conservation policies, will deleteriously affect the Gross Domestic Product (Bildirici & Kayıkçı, 2012; Narayan and Singh, 2007; Shahbaz, Mihai, Tiwari, 2012).

However, economic growth does not granger cause the electricity consumption in Africa, which suggest that there is no transmission mechanism from economic growth to energy consumption. The results confirm the unidirectional causation between economic growth and consumption. The findings run contrary to the conservation hypothesis which posits a uni-directional causality running from economic growth to energy (electricity) consumption. The lacuna in the growth-creating electricity may be due to

the inefficient / inappropriate generation of electricity on the continent.

5. Conclusion and Recommendations

This study reexamined the causality direction between economic growth and energy consumption using data for 21 African countries for the period 1980-2013. The study used panel unit root and cointegration tests to identify the order of integration and long run relationship respectively. The Toda and Yamamoto causality analyses were conducted in line with our objectives.

A stable long-run affiliation subsists between the consumption of energy and economic growth in Africa. The results of Toda and Yamamoto causality test was in support of the growth-lead hypothesis for Africa, as the study discovered positive causality moving from the consumption of electricity energy to the growth of the economy. This signposts that energy is imperative for growth economic in the long-run. Indeed, the consumption of electricity at a higher level tends to be associated with increased growth of the economy. Electricity energy can therefore be described as a veritable engine of sustainable economic growth. Governments are enjoined to work in partnership with the private sector in the development of electricity infrastructure in order to boost its consumption and consequently engender economic growth.

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