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Causal Nexus between Financial Development and Energy Consumption: Evidence from Bootstrap Panel Granger Causality Approach

Uchenna Elike[1]
Alabama A&M University, USA

Emmanuel Anoruo
Coppin State University, USA

Kingsley Nwala
Elizabeth City State University, USA

Abstract

This paper examined the causal relationship between financial development and energy consumption for a panel of nine African countries for the time period running from 1971 to 2014. In particular, the paper applied the bootstrap panel causality Granger causality test. The bootstrap panel Granger approach was adopted by the study because it allows both cross-sectional dependence and heterogeneity across countries. The results from the bootstrap panel Granger causality test indicate the presence of a unidirectional causality running from energy consumption to financial development for Congo Republic, Nigeria, Senegal and Zambia but not vice versa. However, for the rest of the sample countries, the two variables have no causal influence on each other. These results suggest that energy consumption promotes financial development in Congo Republic, Nigeria, Senegal and Zambia.

Keywords: Financial development; Energy consumption; Africa; panel causality; Slope-homogeneity; Cross-sectional dependence

JEL Classification: C33; D53; E44; Q4

1. Introduction

Since the end of colonialism, many African countries have taken steps to promote the growth of their domestic economies. Overtime, these countries have positioned themselves as attractive markets for foreign businesses because of their abundant resources of crude oil, precious metals and cheap labor. These resources have been the major impetus for foreign direct investment (FDI)

[1] Correspondence Author: Uchenna Elike, Email: uchenna.elike@aamu.edu

into the region. Many of these foreign businesses seek to increase profitability and geographic production diversification due to the increasing size of the markets resulting from population increases. In all, these efforts have led to economic growth and prosperity in these regions. As a result of their economic growth, with concomitant prosperity and rising incomes, the demand for energy has increased. Also, energy has become a prime resource critically sought for the production of goods and services. According to the United Nations (2017) report, Africa's population since the 1950s has been growing at an average annual rate of 2.6%. In addition, production of goods and services has also increased in order to sustain the needs of the growing population. This increase in productivity has led to increased energy consumption, and as incomes rise due to the economic prosperity in the region, the need for financial development becomes crucial. There is strong research evidence that financial institutions enhance the fungibility of money and subsequently boost capital formation. Of course, this process consequently leads to expansionary economic activities and increased energy demands.

As these countries are positioning their economies for growth, they are still pondering if there is a connection, and more so a causal relationship, between financial development and energy consumption. In an attempt to explore this connectivity, an understanding of what financial development means becomes vital. Financial development has been defined in various scopes and dimensions by many economists. Some have defined it as the developments in the size, efficiency and stability of and access to the financial system. In this context, financial development will involve the establishment and expansion of institutions, financial instruments, and markets that support the economy's investment and growth processes. Others have defined financial development as an effective financial web that performs the functions of the financial system and eliminates the distortions created by markets. Levine (2004) in a broader sense, described financial development to include some improvements in producing information about possible investments, allocating capital, monitoring and regulating firms, imposing and enforcing corporate governance, trading, investment diversifications, management of risk, mobilization of savings and capital accumulations, and effective exchange of goods and services. From his perspective, financial markets also appear to improve the allocation of capital over time. Countries with developed financial sectors compared to those without them increase investment more in their growing industries and decrease investment more in their declining industries. Furthermore, the efficiency of capital allocation is negatively correlated with the extent of state ownership in the economy, positively correlated with the amount of firm-specific information in domestic stock returns, and positively correlated with the legal protection of minority investors. In particular, strong minority investors' rights appear to curb overinvestment in declining industries. Overall, these financial functions and attributes affect savings, investment decisions, technological innovations, and consequently, economic growth.

The debate on the role and connectivity of financial development on economic growth or on energy consumption of an economy is still unabated. The research on the role of financial development in economic growth can be traced back at least to Bagehot (1873) who claimed that large and well-organized capital markets in England enhanced resource allocation towards more productive investment. He further stated that financial system played a crucial role in stimulating industrialization in England by facilitating the mobilization of capital. Also, efficient financial market through the banks can actually enhance production of goods and leads to economic growth of a country. Little effects are produced when savings remained in the hands of their owners rather than with the banks. When banks are in control of the savings entrusted to them by the public and utilize appropriate credit rationings strategies, general trade of the country increases. Overall, he concluded that a well-organized capital market is crucial for the economic growth of a country.

Another ground-breaking research or study done by Schumpeter (1911), also referred to as supply-leading response school of thought, argued strongly that financial development leads to economic growth. He theoretically proved that a well-developed financial system catalyzes technological innovation and economic growth through the provision of financial services and resources to those entrepreneurs who have the highest probability of successfully implementing innovative products and processes. He further emphasized the importance of innovation and entrepreneurship as crucial sources of economic growth. He also called attention to the role of entrepreneurial leadership in the introduction and establishment of significant innovations, and emphatically explaining that economic development requires a dynamic approach. Schumpeter actually pioneered a socio-economic approach that accounts for factors that are outside of economic theory. Such factors included individual motivations, personality, cultures and historical circumstances, and probably directing our attention to the complex interplay of economic and non-economic factors such as innovation systems, or systems of entrepreneurship. He also stated that financial development plays key role as well in economic growth, and that the causality runs from financial development to growth.

The research on the nexus between financial development and energy consumption is not very robust, as most of the studies on this relationship have focused on Asian and European countries, and less on developing nations. As a contribution, the present study extends the debate on the relationship between financial development and energy consumption for a panel of 9 African countries. It uses the theoretical consistent bootstrap panel Granger causality approach. This methodology simultaneously corrects for the presence of cross-sectional dependency and heterogeneity among the panel members.

The rest of the paper is organized as follows. Following the present introduction, Section 2 furnishes the literature review. Section 3 discusses the methodology. Section 3 presents the data and the descriptive statistics. Section 4 discusses the empirical results. Section 5 provides the conclusions and policy implications of the study.

2. Literature Review

Irrespective of the troves of existing contemporaneous literature positing positive relationships between financial development and economic growth, or financial development and energy consumption, extensive debates are still raging on causality relationships between these variables. A key issue of contention among economists is whether financial development brings about energy consumption, or energy consumption brings about financial development. Different studies employing different causality methodologies continue to espouse different results and conclusions. Based on these contentions, Sardosky (2010) study focused on the effects of financial development on energy consumption. Using 22 emerging economies and the generalized method of moments' estimation techniques to control for endogeneity, he found that increase in financial development, which was measured as stock market variables, increased the demand for energy. These stock market compositions included those traded to GDP, stock market capitalization to GDP, and the stock market turnover. However, other financial development variables like net FDI and deposit money bank assets as a percentage of GDP were found not to have statistically significant effect on energy consumption. He further found that financial development contributes to economic growth by improving investment through level and efficient effects. The level effect thrives on the fact that the financial sector enhances the transfer of idle resources from non-profitable to relatively profitable investments by inducing both domestic and foreign investments. On the other hand, the efficiency effect arises when the development of the financial sector facilitates the provision of more financial resources for highly efficient investment, thereby increasing the demand for energy.

Sadorsky (2011) further examined the impact of financial development on energy consumption in a sample of 9 Central and Eastern European countries frontier economies. He employed several different measures of financial development, including bank related and stock market variables. The results from the dynamic panel demand model used showed a positive and statistically significant relationship between financial development and energy consumption. Increases in financial development measured as deposit money bank assets ratio to GDP, financial system deposit to GDP, and liquid liabilities to GDP (also known as stock market turnover to GDP) increased the demand for energy in these countries. Sadorsky also identified three key avenues through which financial development affects energy consumption: direct, business and wealth effects. The direct effect is observed when financial development aids consumers to borrow easily and cheaply to buy durable consumer goods. This aspect leads to more energy consumption as well.

Kakar et al. (2011) contributed to the debate on causality and relationship between financial development and energy consumption. Their study focused on Pakistan for the period of 1980-2009. Using the co-integration and error correction techniques, as well as the Granger (1987) causality test, they found a significant long-run relationship existed between financial development and energy consumption for Pakistan. However, they did not find such a relationship existing in the short-run. It is also crucial to state that the existence of a long-run unidirectional relationship between financial development and energy consumption was not an isolation case. Granger causality test found money supply and energy consumption also had unidirectional effect, and energy consumption and domestic credit had bi-directional causality effect.

Shahbaz and Lean (2012) using Auto Regressive Distribution Lag Bound model (ARDL) and Granger Causality test confirmed the existence of long-run relationships between Energy Consumption, Financial development, Economic growth, Industrialization and Urbanization in Tunisia. Their study indicated a long-run bidirectional causality existed between Financial Development and Energy Consumption, Financial Development and Industrialization, and Industrialization and Energy Consumption. Based on these findings, their policy implication indicated that these variables are all important to policy makers in Tunisia, and serious considerations must be allotted during policy deliberations.

According to Islam et al. (2013), the nexus between economic growth and energy consumption has been a subject of considerable scrutiny over past decades. They said that there are substantial amount of literature on the existence of long-run relationships between energy consumption and economic growth. However, empirical results on the direction of causality so far remained elusive. Islam (2013) study employed ARDL bound cointegration test and the Vector Error Correction Model (VECM) and found that energy consumption is influenced by financial development and economic growth, both in the short and long run in Malaysia. A bi-directional causality was found between energy consumption and financial development in the long run, but only moved from financial development to energy consumption in the short run. Also, population exerts a significant positive influence on energy consumption in the long run, with its influence

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found to be insignificant in the short run. Based on their study, it is safe to claim that population-energy consumption relationship only holds in the short-run. According to their study also, it is imperative to argue that a growing economy needs more energy consumption, which is exacerbated by population growth. In order to raise the living standards of the people of Malaysia, more goods and services must be produced in the economy. The increase in productivity in turn increases the use of energy. Consequently, economic growth raises the demand for energy in Malaysia.

Ozturk and Acaravci (2013) study focused on the causal log-run relationship between financial development, trade, economic growth, energy consumption, and carbon emissions in Turkey for the period of 1960–2007. Using ARDL and error correction-based Granger causality test, they found in the period studied evidence of short-run unidirectional causal relationship existing from financial development to per capita energy consumption, per capita real income, and square per capita real income. The bounds F-test for co-integration test yields evidence of a long-run relationship between per capita carbon emissions, per capita energy consumption, per capita real income, the square of per capita real income, openness and financial development. They also inferred that improvements in the financial sector will in the short-run result to increase in energy consumption and income in Turkey. In that same study, Ozturk and Acaravci also explained that prosperous and efficient financial intermediation make consumers' loan activities very conducive, thereby making it easier for them to buy items like refrigerators, washing machine and cars which obviously increase their demand for energy. The business effect arises as improved financial development makes it possible for businesses to have easier and less costly access to financial capital that are explored in expanding their business. This eventually culminates into higher energy consumption. In the same vein, developed stock market helps listed companies to have wider range of financing channels and minimize financing costs. It also helps to optimize their asset and liability structures, procure new equipment, and invest in new projects which ultimately results into increased energy demand.

Siddique and Majeed (2015) study contributed to the literature by exploring the impact of energy consumption, trade and financial development on growth in five South Asian countries of India, Nepal, Pakistan, Sri Lanka and Bangladesh from 1980-2010. The panel co-integration approach is employed to examine the long run association and Granger (1987) causality analysis for direction. Their results established non-existence of link between energy consumption and financial development in the short-run. However, financial development, energy and trade positively affected economic growth in the long-run. Bidirectional relationship existed among growth and energy, and unidirectional causality is running from trade and financial development to economic growth. In the same vein, CO2 emissions, energy consumption, financial development and economic growth have long-run relationship in the presence of structural breaks.

Furnoka (2015) stated that there is little doubt that dynamic linkages exist among energy, finance and economic development. He employed heterogeneous panel causality test to examine the relationships between financial development and energy consumption in Asia from 1980-2012. His findings indicated that there is a long-run co-integration relationship between financial development and energy consumption in the region. However, the results pointed to a unidirectional causality from energy consumption to financial development, and not the vice-versa. Financial development did not seem to cause an expansion of energy consumption in Asia. Rather,

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an increase in energy usage would likely engender improvements in the financial sector. Hence, expansion of energy usage could be a driving force behind financial development in Asia.

As previously stated, the contentious debates on causality relationships between financial development, economic growth, and energy consumption are still not abating. In their own contributions, Odusanya et al. (2016) acknowledged that the role of financial development in an economy is being widely discussed in the literature, but no concrete universal causality consensus has been reached. Nonetheless, they stated that there is an agreement that both cross-country and country-specific studies have discussed the significance of financial development, especially as it relates to driving economic growth. They also said that the literature with studies examining the link between financial development and economic growth is infinite, while those investigating the causality relationship between financial development and energy consumption are finite, especially for developing countries. Their study examined the link between financial development and energy consumption in Nigeria from 1971-2014. They employed ARDL bounds co-integration approach and confirmed that a significant positive relationship existed between financial development and energy consumption in Nigeria. They also found that development of the financial sector exerted positive and significant effects both in the short-run and in the long-run on energy consumption. Ultimately, they believed that financial sector's developments will certainly spur an increase in energy consumption via certain channels in Nigeria.

3. Methodology

This paper begins with the application of cross-sectional dependence tests. In particular, it uses the Breusch and Pagan (1980), Pesaran (2004) and Pesaran, et al. (2008) test to examine the existence of cross-sectional dependence across the panel members. O'Connell (1998) suggests that failure to control for contemporaneous correlations between series in a panel could lead to biased inferences. The Breusch and Pagan (1980) Lagrange Multiplier (LM) test is based on the estimation of the following panel data model:

$$y_{it} = \alpha_i + \beta' x_{it} + \epsilon_{it} \tag{1}$$

Where y is the depend variable (in our case financial development or energy consumption), i represents the cross-sectional dimension, t is the time index, x_{it} is kx1 vector of independent variables. α_i and β_i respectively, are the individual intercepts and slope coefficients that can vary across panel members. The LM CD test involves testing the null hypothesis of no cross-sectional dependence [i.e. H_o: $Cov(u_{it}, u_{ij}) = 0$, for all t and $i \neq j$] against the alternative, H_1: $Cov(u_{it}, u_{jt}) \neq 0$, for at least one pair of $i \neq j$. The LM statistic for cross sectional dependency test is obtained as follows:

$$\mathrm{LM} = \mathrm{T} \sum_{t=1}^{N-1} \sum_{J=I+1}^{N} (\hat{\rho}_{ij}) \tag{2}$$

Where N represents *the* number of cross sections, T stands for the sample size and $\hat{\rho}_{ij}$ denotes the correlation coefficient between the residuals obtained from the individual OLS estimations. The test statistic is distributed as $\chi n(n-1)/2$. Pesaran (2004) argues that the LM test statistic is valid in the cases where N is small and T is sufficiently large. To overcome this drawback, Pesaran (2004) introduced a scaled version of the Breusch and Pagan (1980) LM test statistics which can be applied when $T \rightarrow \infty$ and $N \rightarrow \infty$. The scaled version of the LM procedure is given by:

 ISSN 1927-033X

$$CD_{lm} = \sqrt{T/_{N(N-1)}} \sum_{T=1}^{N-1} \sum_{j=i+1}^{N} \left(\hat{\rho}_{ij}^{2}\right) \quad (3)$$

The CD_{lm} statistic by *assumption* is asymptotically normally distributed. As such, the CD_{lm} is applicable when either T>N or N>T. A drawback of the CD_{lm} test is that it tends to exhibit size distortions when N is large and T is small. To alleviate this weakness, Pesaran (2004) proposed the following test:

$$CD = \sqrt{2T/_{N(N-1)}} \sum_{T=1}^{N-1} \sum_{j=i+1}^{N} \left(T\hat{\rho}_{ij}^{2} - 1\right) \quad (4)$$

Pesaran (2004) suggests that the CD procedure is robust to heterogeneous dynamic models as long as the unconditional means of y_{it} and x_{it} are time-invariant. Pesaran, *et al*. (2008) argue that the standard cross-sectional dependence tests loose power when the population average pair-wise correlations are zero while the underlying individual population pair-wise correlations are non-zero. To address this weakness, Pesaran, *et al*. (2008) introduced the following bias-adjusted LM test:

$$LM_{adj} = \sqrt{2/_{N(N-1)}} \sum_{T=1}^{N-1} \sum_{j=i+1}^{N} \left(\hat{\rho}_{ij}\right) \frac{(T-k-1)-\mu_{Tij}}{VT_{ij}} \quad (5)$$

Where μ_{Tij} and ν_{Tij} are the exact mean and variance of $(T-k-1)\hat{\rho}_{ij}^{2}$. The LM_{adj} test, by assumption follows asymptotically standard normal distribution. The null hypothesis under the LM, CD_{lm}, CD and LM_{adj} tests is that there is no cross-sectional dependence among the members of the panel. The null hypothesis is rejected if the calculated test statistic is greater than the critical value at the conventional levels. Details regarding these various cross-sectional dependence tests can be found in Pesaran, *et al*. (2008).

3.1. Slope Homogeneity

In conducting panel causality test, it is important to determine whether or not the slope coefficients in the model are homogenous. The Wald test is frequently used to test the null hypothesis of slope homogeneity against the alternative hypothesis of slope heterogeneity. The test involves testing in equation (1) the following null hypothesis:

$$H_0: \beta_1 = \cdots = \beta_N \quad (6)$$

Mark *et al*. (2005) point out that the Wald statistic is asymptotically distributed as Chi-square with N-1 degrees of freedom. The Wald test provides reliable results when the following conditions are met: (i) the cross-section dimension (N) is relatively small and the time span (T) of panel is large, (ii) the explanatory variables are strictly exogenous, and (iii) the error variances are homoscedastic. Swamy (1970) developed slope homogeneity test by relaxing the homoscedasticity assumption. Pesaran and Yamagata (2008) maintain that the slope homogeneity test proposed by Swamy (1970) is appropriate in the case where N is small relative to T. To mitigate this restriction, they proposed the Δ test which is designed to test for slope homogeneity in large panels. The Δ statistic follows an asymptotic standard normal distribution provided that the error terms are normally distributed and the condition that $(N,T) \to \infty$, as long as $N/T \to \infty$. The Δ test is

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standardized version of the Swamy (1970) procedure for testing slope homogeneity which is given by:

$$\tilde{S} = \sum_{i=1}^{N} \left(\hat{\beta}_i - \tilde{\beta}_{WFE}\right)' \frac{X_i' M_\tau x_i}{\hat{\sigma}_i^2} \left(\hat{\beta}_i - \tilde{\beta}_{WEF}\right) \qquad (7)$$

Where $\hat{\beta}_i$ represents the pooled OLS estimator, $\tilde{\beta}_{WFE}$ stands for the weighted fixed effect pooled estimator, M_τ denotes an identity matrix while $\hat{\sigma}_i^2$ represents the estimator of the error variance, σ_i^2. When N is fixed and $T \rightarrow \infty$ the S test has and asymptotic chi-square distribution with k(N-1) degrees of freedom. The standardized dispersion statistic as proposed by Pesaran and Yamagata (2008) is given by:

$$\tilde{\Delta} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - k}{\sqrt{2k}}\right) \qquad (8)$$

The Δ statistic follows an asymptotic standard normal distribution provided that the error terms are normally distributed and the condition that $(N,T) \rightarrow \infty$, as long as $N/T \rightarrow \infty$. Pesaran and Yamagata (2008) proposed an additional procedure known as the bias adjusted statistic (Δ_{adj}) designed to improve the small sample properties associated with the Δ statistic. The bias adjusted statistic (Δ_{adj}) is based on:

$$\tilde{\Delta}_{adj} = \sqrt{N}\left(\frac{N^{-1}\tilde{S} - E(\tilde{z}_{it})}{\sqrt{var(\tilde{z}_{it})}}\right) \qquad (9)$$

Where the mean $E(\tilde{z}_{it})$ = k and the variance $var(\tilde{z}_{it})$ = 2k(T-k-1)/(T+1). Details of these various slope homogeneity procedures can be found in Pesaran and Yamagata (2008).

3.2. Bootstrap Panel Granger Causality Test

This study applies the bootstrap panel Granger causality test advanced by Kónya (2006). This approach has attractive features. Firstly, it does not assume that the panel is homogeneous, so it is possible to test for Granger-causality on each individual panel member separately. However, since contemporaneous correlation is allowed across countries, it makes possible to exploit the extra information provided by the panel data setting. Secondly, this approach does not require pretesting for unit roots and cointegration (since country specific bootstrap critical values are generated), though it still requires the specification of the lag structure. This is an important feature since the unit-root and cointegration tests in general suffer from low power, and different tests often lead to contradictory outcomes. Thirdly, this panel Granger causality approach allows the researcher to detect for how many and for which members of the panel there exists one-way Granger-causality, two-way Granger-causality or no Granger-causality. For instance, it does not require pre-testing such unit root and cointegration. Above all, this approach has the ability to account for both cross-sectional dependence and heterogeneity that may be present in the panel. The Kónya (2006) bootstrap panel Granger causality test is based on the two system of equations given below:

$$FD_{1,t} = \alpha_{1,1} + \sum_{k=1}^{ly1} \beta_{1,1,K} FD_{1,t-k} + \sum_{k=1}^{lx1} \varphi_{1,1,K} EC_{1,t-k} + \epsilon_{1,1,t}$$

$$FD_{2,t} = \alpha_{1,2} + \sum_{k=1}^{ly1} \beta_{1,2,K} FD_{1,t-k} + \sum_{k=1}^{lx1} \varphi_{1,2,K} EC_{1,t-k} + \epsilon_{1,2,t}$$

$$\vdots$$

$$FD_{N,T} = \alpha_{1,N} + \sum_{k=1}^{ly1} \beta_{1,N,K} FD_{N,t-k} + \sum_{k=1}^{lx1} \varphi_{1,N,K} EC_{N,t-k} + \epsilon_{1,N,t} \quad (10)$$

and

$$EC_{1,t} = \alpha_{2,1} + \sum_{k=1}^{ly2} \beta_{2,1,K} FD_{1,t-k} + \sum_{k=1}^{lx2} \varphi_{2,1,K} EC_{1,t-k} + \epsilon_{2,1,t}$$

$$EC_{2,t} = \alpha_{2,2} + \sum_{k=1}^{ly2} \beta_{2,2,K} FD_{1,t-k} + \sum_{k=1}^{lx2} \varphi_{2,2,K} EC_{1,t-k} + \epsilon_{2,2,t}$$

$$\vdots$$

$$EC_{N,T} = \alpha_{2,N} + \sum_{k=1}^{ly2} \beta_{1,N,K} FD_{N,t-k} + \sum_{k=1}^{lx2} \varphi_{1,N,K} EC_{N,t-k} + \epsilon_{2,N,t} \quad (11)$$

Where EC represents energy consumption (kg of oil equivalent per capita) and FD stands for financial development proxied by domestic credit to private sector (% of GDP). In this system, each equation has different predetermined variables and the error terms are assumed to be cross-sectional dependence. Thus, these set of equations are the seemingly unrelated regressions (SUR) system. N represents the number of countries in the panel (in our case 9); t stands for the time period (t=1….T); m_{lx} and m_{ly} are the maximum lag lengths respectively for financial development and energy consumption equations. The maximum lags are determined by the Schwartz Bayesian Criterion (SBC). *i* represents the time dimension; α_i and β_i stand for the individual and slope coefficients, respectively. Equations (10) and (11) are SUR system since in each equation in the system has different predetermined variables and the error terms are assumed to be cross-sectional dependent. In equations (10) and (11), Granger causality test for country *i* can be ascertained by testing the following null hypotheses:

(i) the rejection of the null hypothesis φ_{1i} = 0 for all *i*, implies that energy consumption (EC) does not Granger-cause financial development (FD).

(ii) the rejection of the null hypothesis β_{2i} = 0 for all *i*, suggests that financial development does not Granger-cause energy consumption.

(iii) if (i) and (ii) hold, there is no Granger causality between energy consumption and financial development.

(iv) if (i) holds but (ii) does not, there is a unidirectional causality from energy consumption to financial development.

(v) if (i) does not hold but (ii) does, there is a unidirectional causality from financial development to energy consumption.

(vi) if (i) and (ii) do not hold, there is bidirectional causality between energy consumption and financial development.

4. Data and Descriptive Statistics

The data set consists of annual observations on financial development [proxied by domestic credit to private sector (% of GDP)] and energy consumption (kg of oil equivalent per capita). The data on financial development (i.e. domestic credit) were obtained from the International Monetary Fund, International Financial Statistics. The data on energy consumption (kg of oil equivalent per capita) were retrieved from IEA Statistics OECD/IEA 2014 (http://www.iea.org/stats/index.asp). The sample period runs from 1971 through 2014. The sample countries are Benin, Cameron,

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Republic of Congo, Nigeria, Senegal, Sudan, South Africa, Togo and Zambia. For empirical exposition, the data on both financial development and energy consumption were converted to natural logarithm for consistency.

The descriptive statistics for financial development and energy consumption are presented in Panels A and B of Table 1. From Panel A of Table 1, it can be seen that the highest mean value (99.83%) for financial development is recorded by South Africa. While Sudan displayed the lowest mean value of 8.30%. The standard deviations varied from a high of 35.46% for South Africa to a low of 3.98% for Sudan. The Jarque-Bera statistics indicate that the null hypothesis of the financial development variables are normally distributed, and should be rejected at least, at the 10% significance level for Cameroon, Nigeria, South Africa and Zambia. Panel B of Table 1 displays the summary statistics for energy consumption. South Africa records the highest mean value (2,431.12) of energy consumption. While Senegal exhibited the lowest mean value of 254.38. The standard deviations ranged from a high of 251 for South Africa to a low of 26.73 for Senegal. The Jarque-Bera statistics suggest that the null hypothesis that the energy consumption series are normally distributed should be rejected at least, at the 10% significance level for Cameroon and Republic of Congo. The minimum and maximum statistics show for both the financial development and energy consumption series have fluctuated over the years. For instance, the value of financial development for Benin varied from a minimum of 5.42% to a maximum of 31.84% for the time period under study.

Table 1: Descriptive Statistics

Country	Mean	Max	Min	STD	Skew	Kurt	J-Bera	Prob.
Panel A: Financial Development (Private Domestic Credit % of GDP)								
Benin	17.40	31.84	5.42	7.73	0.20	1.82	2.83	0.24
Cameroon	16.31	31.24	5.94	8.24	0.43	1.68	4.53^{*}	0.10
Congo, Rep.	12.46	31.68	2.10	7.05	0.34	2.71	0.99	0.61
Nigeria	13.48	38.39	4.70	6.38	2.07	8.59	88.80^{***}	0.00
Sudan	8.30	13.96	1.62	3.98	-0.39	1.73	4.08	0.13
Senegal	24.11	37.55	13.67	7.01	0.17	1.86	2.58	0.28
Togo	21.06	37.68	8.63	6.62	0.20	2.60	0.58	0.75
South Africa	99.83	160.12	53.97	35.46	0.22	1.48	4.59^{*}	0.10
Zambia	11.92	24.23	4.79	5.57	0.81	2.54	5.16^{*}	0.08
Panel B: Energy Consumption (kg of oil equivalent per capita)								
Benin	353.85	416.80	288.77	29.90	-0.10	2.47	0.60	0.74
Cameroon	402.40	443.55	327.20	32.75	-1.11	3.11	9.06^{***}	0.01
Congo, Rep.	337.36	552.49	220.07	77.47	1.21	4.88	17.28^{***}	0.00
Nigeria	694.51	798.30	579.10	53.50	-0.31	2.64	0.93	0.63
Sudan	408.08	491.38	351.21	35.34	0.69	2.85	3.55	0.17
Senegal	254.38	305.01	206.87	26.73	-0.02	1.98	1.93	0.38
Togo	371.42	492.16	303.18	56.13	0.56	1.91	4.51	0.11
South Africa	2431.12	2913.13	1912.97	251.58	-0.44	2.41	2.08	0.35
Zambia	690.92	882.61	588.61	93.89	0.63	2.08	4.48	0.11

***, and * rejection of normality assumption at the 1% and 10%, levels of significance, respectively.

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5. Empirical Results

The empirical analysis of the study begins with the discussion of the results from the cross-sectional dependence tests. Table 2 furnishes the results from the LM, CDlm and the CD cross-sectional dependence tests. The results suggest that the null hypothesis of no cross-sectional dependence across the countries in the panel should be rejected. For instance, the test statistics for financial development are 86.44, 5.95, -4.16, respectively for the LM_{BP}, CD_{lM} and CD procedures are statistically significant at the 1 percent level. Equally, for energy consumption variable, the cross-sectional statistics are 81.29, 5.34 and -4.23, respectively for the LM_{BP}, CD_{lM} and CD procedures. These test statistics reject the null hypothesis of no cross sectional dependence at the 1 percent level of significance. In addition to the cross-sectional dependence tests for the individual variables, the study also conducted test for the entire model. Panel C of Table 2 displays the results for the model. Again, the results reject the null hypothesis of no cross-sectional dependence at the 1 percent level of significance. The test statistics are 329.36, 34.57 and -2.88, respectively for the LM_{BP}, CD_{lM} and CD procedures. In all, these results suggest that the null hypothesis of no cross-sectional dependence should be rejected. These results imply that shocks to either financial development or domestic credit in one of the sample countries can be easily transmitted to the other countries in the panel.

Table 2: Cross-Sectional Dependence Test Results

	Test Stat	**Probability**
Panel A: Financial Development (FD)		
LM_{BP} (Breusch and Pagan 1980)	86.44^{***}	0.00
CDlm (Pesaran 2004)	5.95^{***}	0.00
CD (Pesaran 2004)	-4.16^{***}	0.00
Panel B: Energy Consumption (EC)		
LM_{PB} (Breusch and Pagan 1980)	81.29^{***}	0.00
CDlm (Pesaran 2004)	5.34^{***}	0.00
CD (Pesaran 2004)	-4.23^{***}	0.00
Panel C: Model		
LM_{BP} (Breusch and Pagan 1980)	329.36^{***}	0.00
CDlm (Pesaran 2004)	34.57^{***}	0.00
CD (Pesaran 2004)	-2.88^{***}	0.00

*** indicates rejection of the null hypothesis of no cross-sectional dependence at the 1%

The paper next uses the slope homogeneity procedures developed by Pesaran and Yamagata (2008) to determine whether or not the slopes for the various panel members are homogeneous. Table 3 presents the results from the $\tilde{\Delta}$, $\tilde{\Delta}$adj and $\tilde{S}$ slope homogeneity testing procedures. The results from these tests overwhelmingly reject the null hypothesis of slope homogeneity. For example, the test statistics are 8.41, 8.71 and 14.66, respectively for $\tilde{\Delta}$, $\tilde{\Delta}$adj and $\tilde{S}$ procedures. These test statistics are all statistically significant at the 1 percent level. The finding that the slopes for the panel members are heterogeneous suggest that the direction of causal linkages between financial development and energy consumption may differ across the nine African countries under study.

Table 3: Slope Homogeneity Test Results

	Test Stat	Probability
$\tilde{\Delta}$	8.41^{***}	0.00
$\tilde{\Delta}_{adj}$	8.71^{***}	0.00
$\tilde{S}$	14.66^{***}	0.00

*** indicates the rejection of the null hypothesis of slope homogeneity at the 1% level of significance

The study next applies the bootstrap panel causality test based on the finding of existence of cross-sectional dependence and heterogeneity across the sample countries. Tables 4A and 4B furnish the results from the bootstrap panel causality tests. The results in Table 4A provide evidence of causality running from energy consumption to financial development for Republic of Congo, Nigeria, Senegal, and Zambia. The test statistics 14.44, 15.46, 16.45 and 15.92, respectively for Republic of Congo, Nigeria, Senegal, and Zambia. These test statistics are statistically significant at the 5 percent level. The results suggest that energy consumption in Republic of Congo, Nigeria, Senegal, and Zambia promotes financial development. However, the results fail to reject the null hypothesis of non-causality from energy consumption to financial development in the cases of Benin, Cameroon, South Africa, Sudan, and Togo. For these five countries, energy consumption is inconsequential to financial development.

Table 4A: Bootstrap Panel Granger Causality Test Results

H_0: Energy Consumption does not Granger-Cause Financial Development (EC $\nrightarrow$ FD)				
Country	**Wald Statistic**	**Bootstrap Critical Value**		
		10%	**5%**	**1%**
Benin	6.16	8.50	11.34	17.75
Cameroon	1.99	8.66	11.89	20.17
Congo, Rep.	14.44^{**}	9.29	12.55	20.48
Nigeria	15.46^{**}	8.48	11.16	18.50
Senegal	16.45^{**}	8.77	11.91	20.33
South Africa	2.63	8.11	10.91	18.10
Sudan	0.57	9.55	12.84	21.72
Togo	0.59	9.24	12.29	19.91
Zambia	15.92^{**}	9.49	12.49	20.18

** indicates level of significance at the 5% level. The bootstrap critical values are obtained from 10,000 replications.

Table 4B reveals the results of test of non-causality from financial development to energy consumption. The results indicate that null hypothesis that financial development does not Granger-cause energy consumption should not be rejected in all of the cases. The test statistics 2.06, 3.70, 7.57, 2.41, 6.12, 0.51, 0.35, 2.03 and 2.11, respectively for Benin, Cameroon, Republic of Congo, Nigeria, Senegal, South Africa, Sudan, Togo and Zambia are all statistically insignificant at the conventional levels. Taken together, the results reveal that energy consumption and financial development do not have influence on each other in the cases of Benin, Cameroon, South Africa, Sudan, and Togo. However, for Republic of Congo, Nigeria, Senegal, and Zambia, the results provide evidence of bidirectional causality from energy consumption to financial development, but not vice versa. The finding of the study is consistent with Furuoka (2015) who

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found evidence of unidirectional causality from energy consumption to financial development for a group of Asian countries. However, the results from this study are at odds with Sadorsky (2011) who finds that increases in financial development promote the demand for energy in Central and Eastern European frontier economies. The differences in the results could be attributed to the different methodologies adopted by the two studies and the quality of the data sets used by each study.

Table 4B: Bootstrap Panel Granger Causality Test Results

H_0: Financial Development does not Granger-Cause Energy Consumption (FD ↛ EC)

Country	**Wald Statistics**	**Bootstrap Critical Value**		
		10%	**5%**	**1%**
Benin	2.06	7.60	9.78	15.28
Cameroon	3.70	8.26	11.35	19.60
Congo, Rep.	7.57	7.99	10.76	18.21
Nigeria	2.41	7.91	10.60	17.24
Senegal	6.12	7.65	10.20	17.09
South Africa	0.51	7.57	10.20	16.64
Sudan	0.35	7.80	10.43	17.38
Togo	2.03	7.67	10.30	16.70
Zambia	2.11	7.84	10.50	17.13

The bootstrap critical values are obtained from 10,000 replications.

6. Conclusions

This paper has used the bootstrap panel causality test to examine the causal relationship between financial development and energy consumption for a panel of 9 African countries for the time period of 1971 through 2014. In particular, the study first used testing procedures advanced by Pesaran (2004) CD_{lm}, CD and the bias adjusted CD to test for the presence of cross-sectional dependence within the panel. To determine whether or not the slopes for the panel members are homogeneous, the study applied the slope homogeneity test developed by Pesaran and Yamagata (2008). To draw causal inference between energy consumption and financial development, the study implemented the bootstrap panel causality test introduced by Kónya (2006). This bootstrap panel causality approach is preferred because it has the ability to correct for both the presence of cross-sectional dependence and heterogeneity across panel member countries.

The results reveal evidence of cross-sectional dependence in both the variables and the entire model, indicating that the panel member countries are susceptible to energy and financial shocks from each other. The results from the slope homogeneity tests suggest that the slopes are heterogeneous across countries. The results from the bootstrap panel Granger causality tests provide evidence of causality running from energy consumption to financial development for Republic of Congo, Nigeria, Senegal, and Zambia but not vice versa. However, for Benin, Cameroon, South Africa, Sudan and Togo, the results show that financial development and energy consumption are independent, as they have no causal influence on each other.

The results from this study indicate that energy policies in Republic of Congo, Nigeria, Senegal, and Zambia have ramifications for their financial sectors, but not vice versa. Simply put,

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increases in energy consumption can serve as a driving force behind financial development in these four countries. The fact that the present study did not find evidence of a unidirectional causality from the financial sector to the energy sector for all of the sample countries suggests that policymakers may want to formulate and implement policies that encourage the financial sector to give appropriate and sufficient financial support to the energy sector. In the absence of such policies, financial sectors will continue to lack the impetus to kindle development in the energy sector.

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