COAL CONSUMPTION AND ECONOMIC GROWTH IN NIGERIA: A TWO-STEP RESIDUAL-BASED TEST APPROACH TO COINTEGRATION

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Abstract:

This examines the relationship between coal consumption and economic growth for Nigeria over the period 1980-2010 by using a two-step residual-based approach to co integration and Granger causality test. The empirical results of this study reveal that coal consumption and economic growth in Nigeria are moving together in the long run. Also, the causality results indicate a unidirectional relationship running from economic growth to coal consumption. This means that continuous economic growth simultaneously generates a continuous rise in coal consumption. In this case, coal consumption is fundamentally driven by real GDP. Since economic growth directly causes coal consumption and not vice versa, the closure or slow down of coal consumption in Nigeria should not have, in general, a significant negative impact on Nigerian economy.

Keywords: Coal Consumption, Economic Growth, Causality, Cointegration

Introduction

It is well documented that long term global economic growth cannot be achieved without adequate and affordable energy supplies, which will require continuing significant contributions from fossil fuels, including coal. As such, coal plays a unique role in meeting the demand for secured energy, as it is globally the most abundant and economical of fossil fuels. At current production levels, proven world coal reserves are estimated to last 147 years, in contrast to oil and gas which are estimated to last 41 and 63 years, respectively . It is also projected that the greatest demand for fossil fuels will be coal, which will remain the second largest primary fuel source until 2030 (Wolde-Rufael, 2010).

According to Energy Information Administration (2009) World coal consumption is projected to increase from 127.5 quadrillion Btu in 2006 to 190.2 quadrillion Btu in 2030. In 2006, coal accounted for 27 percent of world energy consumption. Of the total coal produced worldwide in 2005, 62 percent was shipped to electricity producers, 34 percent to industrial consumers, and most of the remaining 4 percent to the residential and commercial sectors. Coal's share of total world energy consumption is projected to increase to 28 percent in 2030, and its share in the electric power sector is projected to remain relatively constant at 42 percent from 2006 to 46 percent in 2030.

Nigeria today is seen as one of the greatest developing nations in Africa with highly endowed coal energy resources. However, increasing access to energy in Nigeria has proved to be not only a continuous challenge but also a pressing issue with the international community. Coal is one of the oldest commercial fuel used in Nigeria but Since oil was discovered, coal was given less relevance and became highly neglected. With a reserve of over 2 billion metric tonnes, Nigeria produces not more than 200000 to 600000 tonnes yearly (Odularo and Okonkwo, 2009).

Despite the fact that coal consumption is an important source of energy for Nigeria, no study has been carried out on the relationship between coal consumption and economic growth in Nigeria to best of the author's knowledge. Therefore, This paper aims to fill this gap.

The remainder of this paper is organised in the following manner. A brief literature review will be presented in Section 2. The discussion on the data and methodology used in this study are demonstrated in Section 3. Lastly, Sections 4 and 5 report the empirical results and conclusion, respectively.

Literature review

The causal relationship between coal consumption and economic growth has a number of policy implications. First, if an increase in coal consumption causes an increase in economic growth. In this situation, energy conservation policies which reduce coal consumption may adversely affect economic growth. On the other hand, a number of explanations may be presented in which an increase in coal consumption has a negative impact on economic growth. Such a negative impact of coal consumption on economic growth could be attributed to an inefficient and excessive use of coal consumption.

Second, if there is unidirectional causality running from economic growth to coal consumption. In this case, energy conservation policies aimed toward the reduction of coal consumption may not have an adverse impact on economic growth. However, it is possible that an increase in economic growth may actually reduce coal consumption which may indicate that an economy is becoming less coal intensive.

Additionally, if there is two-way relationship between coal consumption and economic growth. This complementary relationship opens the possibility that energy conservation policies which reduce coal consumption may, in turn, impact economic growth. Likewise, such fluctuations in economic growth will be transmitted back to coal consumption. Finally, if there is absence of causality between coal consumption and economic growth. Under this scenario, the reduction in coal consumption through energy conservation policies will not impact economic growth.

Previous studies provide a range of results for a relatively small number of countries on the causal relationship between coal consumption and economic growth. Yoo (2006) investigates the causal relationship between coal consumption and economic growth in Korea for the period 1968 to 2002 by deploying unit roots, cointegration, and Granger causality based on error correction model (ECM). The results show that there exists bidirectional between coal consumption and economic growth. Thus, in order not to adversely affect economic growth Korea should endeavor to overcome the constraints on coal consumption. Similarly, using Toda-Yamamoto procedure and nonlinear Granger causality test to examine the relationship between coal consumption and economic growth of the Polish economy in transition for the period Q1:2000 to Q4: 2009, Gurgul and Lach (2011) reports neutrality hypothesis with respect to coal consumption and economic growth. However, calculations for the pairs lignite-GDP and total coal consumption-GDP showed the existence of a significant nonlinear causality from coal usage to economic growth. Also, each coal related variable was found to have a nonlinear impact on employment. Being relatively short length of available time series, the study additionally employed bootstrap techniques, yet, the result computed by both methods did not exhibit significant differences. Thus, the conservation policy suggest that hard mines in Poland should have no significant repercussions on economic growth. However, this does not seem to be true for lignite mines.

Furthermore, Kumar and Shahbaz (2010) applied endogenous two-break unit root test, autoregressive distributed lag (ARDL) model, Phillip Hansen's fully modified ordinary least squares (FMOLS) to examine structural breaks, cointegration, and causality test for Pakistan over the period 1971-2009, the results reveal a cointegrating relationship between real income, real capital stock, and coal consumption. The elasticity coefficient with respect to coal consumption is positive and significant. Moreover, the result of causality test imply bidirectional causality between income and coal consumption in the short run. Moreover, there is unidirectional causality in the short run from capital and labour income. However, in the long run results of the causality tests imply that capital, labour, and coal consumption Granger causes income in the long run. Similarly, Yilmaz and Uslu (2007) descriptively analyzed the role of coal consumption on sustainable development of Turkey from 1994-2004, the results of their analysis suggests that coal still has a potential of 220-240 years with the consumption capacity at the moment. The primary energy consumption is estimated to be 298 Mtoe, the production is estimated to be 70 Mtoe, the ratio of production to consumption will drop to a level of 23.5% and this situation will cause serious risks for sustainable development.

Moreover, Bloch *et al.* (2012) examines the relationship between coal consumption and economic growth using cointegration and vector error correction model for the period 1997 to 2008 and 1965 to 2008 for the supply side and demand side analysis respectively. The premise behind selecting these is the availability of data. Variables used in supply side analysis are output, labour, capital and coal consumption, while in demand side analysis are income, coal price, carbon emissions and coal consumption. The results show that there is unidirectional causality running from coal consumption to output in both the short and long run under supply side analysis, while there is also unidirectional causality running from income to coal consumption in the short and long run under demand side analysis. The result further reveal bidirectional causality between coal consumption and pollutant emission both in the short run. Hence, it is very difficult for China to pursue a greenhouse gas abatement policy through reducing coal consumption. A more recent study by Li and Leung (2012) re-examine the relationship between coal consumption and real GDP of China with the use of panel data for the 31 Provinces from the period 1985-2008 and employed unit root tests and panel cointegration test. The findings show that coal consumption and economic growth are cointegrating in all regional groupings. The causality test reveal that there is bidirectional relational between coal consumption and economic growth in coastal and central regions whereas causality is unidirectional from economic growth to coal consumption in the Western region. Thus, the energy conservation policies will not adversely affect the economic growth of the Western region but such policies will likely to have negative repercussions on the economy of coastal and central regions where most of the coal intensive industries are situated.

The first study in the energy economics literature that investigates the relationship between coal consumption and economic growth for a large group of transition countries is the one by Apergis and Payne (2010a) applied vector correcting model paralleling the Johansen cointegration technique to investigate the relationship between coal consumption ant economic growth for the panel of 25 OECD countries over the period 1980-2005. The panel cointegration test reveals that there exist a long run relationship between economic growth, coal consumption, real gross fixed capital formation and the labour force. Also, positive and statistically significant for the coefficient of real gross fixed capital formation and the labour force are reported, whereas the coefficient coal consumption is negative and statistically significant. Furthermore, the results of panel vector error correction model reveal two-way relationship between coal consumption and economic growth in both the short and long run.

In their later contribution, Apergis and Payne (2010b) examines the relationship between coal consumption and economic growth for 15 emerging markets economies over the period 1980-2006 and employed fully modified OLS (FMOLS) technique for heterogeneous cointegrated panels. The results suggest a long run equilibrium relationship between real GDP, coal consumption, real gross fixed capital formation, and the labour. The results also suggest that both real gross fixed capital formation and the labour force have a significant positive impact on real GDP, while coal consumption has a significant negative impact. However, the panel causality tests show bidirectional causality between coal consumption and economic growth in both short and long run.

In a more extensive study Jinke *et al.*(2008) tested the differences between the causal relationship between coal consumption and economic growth for the major OECD and non-OECD countries for the period 1980-2005 using the simple two-step test by Engle and Granger, Johansen vector autoregression (VAR) test and error correction model. The results indicates a unidirectional causality running from GDP to coal consumption for Japan and China, and neutrality causality between the coal consumption and economic growth was reported for India, South Korea, and South Africa. However, the series are not cointegrated in the case of United State. Similarly, Wolde-Rufael (2010) employed Toda and Yamamoto within a vector autoregressive (VAR) framework by including capital and labour as intermittent variables to verify whether there is causality between real GDP and coal consumption for the period 1965-2005 for six major coal consuming countries. The results indicates unidirectional causality from coal consumption to economic growth in India and Japan while, the opposite causality running from real GDP to coal consumption was reported for China and South Korea. However, two-way causality relationship between economic growth and coal consumption was evidenced for South Africa and United States. Additionally, variance decomposition analysis seems to confirm our Granger causality results. The policy implication is that measures adopted to mitigate the adverse effects of coal consumption may be a viable option without harming economic growth in China and South Korea. While for the remaining four countries conservation measures can harm economic growth.

Another study by Jinke *et al.* (2009) examined the differences in coal consumption patterns and economic growth between developed and developing countries. The authors considered the panel data over the period 1980-2005 by employing the Granger causality tests. The results reveal absence of similar causal relationship between coal consumption and GDP in major developed and developing countries. Therefore, they all should examine how coal use is linked with economic development and make a scientific policy for coal energy to cut carbon dioxide ($CO_{2)}$ emissions to meet the standard stipulated in Kyoto protocol. In recent study by Jinke and Li (2011) examines the causal relationship between coal consumption and economic growth for China and India for the period 1965-2006 utilizing Granger causality tests based on error correction model (ECM), their results indicate that there exists a unidirectional causality from economic growth proxied by GDP to coal consumption in China, while the reverse is the case for India. Therefore, the efforts to implement coal saving and emission reduction policies would slow down the economic growth in India while China may overcome heavy dependence on coal in the long run by relying more on hydro power and natural gas.

Data and methodology

Annual time series data, which covers the period 1980 to 2010 are utilised in this study. All the variables are expressed in logarithmic form. The coal consumption is obtained from Energy Information Administration (EIA) and data for real GDP is retrieved from Central Bank of Nigeria Statistical Bulletin. The coal consumption is defined in thousands of metric tons and real GDP is proxied for economic growth.

On the methodological front, most of the macroeconomic time series data are non stationary. It is convenient to estimate relationships through the regression method only if the series are stationary. To check whether or not the variables under consideration are stationary. One of the test for stationary which is Augmented Dicker Fuller (ADF) test is applied to the natural logs of the data series.

According to Engle and Granger (1987), if two time-series are both non-stationary, while the linear combination of two time-series would be stationary, thus, the two time-series are cointegrated. Tests of cointegration which include the simple two-step test by Engle and Granger (1987) is adopted for this study . As two time-series of LRGDP and LCOLC are tested for stationary, the two-step test EG is estimated as follows:

First: Estimate cointegration equation is of the following form:

$$LRGDP_t = c + \beta LCOLC_t + STATRESID_t \text{ --- } (1)$$

To obtain c, β and $STATRESID_t = LRGDP_t - C - \beta LCOLC_t$

Secondly: Secondly: if the ADF test indicates $STATRESID_t \Leftrightarrow I(0)$, thus $STATRESID_t$ is stationary, and $LRGDP_t$ and $LCOLC_t$ are cointegrated. The OLS would be estimated via the above model of coal consumption and RGDP series to obtain the $STATRESID_t$, the ADF test for $STATRESID_t$ will be conducted.

Cointegration implies the existence of Granger causality. However, it does indicate the direction of the causality relationship. Therefore, the pairwise Granger causality is employed to detect the direction of causality through the following equations:

$$RGDP_t = a + \sum_{i=1}^{p} \mu_i RGDP_{t-1} + \sum_{j=1}^{q} \rho_j COLC_{t-1} + v_t \text{ ---------------------- } (2)$$

$$COLC_t = b + \sum_{i=1}^{m} \gamma_i COLC_{t-1} + \sum_{j=1}^{n} \delta_j RGDP_{t-1} + \varepsilon_t \text{ -------------------- } (3)$$

where RGDPt and COLCt are defined as RGDP and COLC observed over t time periods; p and q represents the number of lags; μ, ρ,γ, and δ are parameters to be estimated; v_t and ε_t represents the serially uncorrelated error term.

Empirical results

The study first tested for unit root in variables using the Augmented Dickey Fuller test. The results of the test are shown below in Table 1

Table 1: Unit Root Test

Variable	ADF test at Level	ADF test at first Difference
RGDP	2.016776	-3.940960***
COLC	-1.733176	-8.153546***

Source: author's calculation using EVIEWS software, ***indicates level of significance at 1%

Table 1 presents the results of Augmented Dickey Fuller unit root test on the variables at their level and differenced values. The summary of the results indicates that all the variable are not stationary at their level values. However, the test statistic by ADF revealed that all the variables are stationary at their first difference at 1% level of significance.

Table 2 : Unit Root for STATRESID

Variable	ADF test at Level
STATRESID	-3.089202**

Source: author's calculation using EVIEWS software, **indicates level of significance at 5%

Having OLS is estimated via the above model of coal consumption and RGDP series, Table 2 indicates the test results for RGDP and coal consumption at the corresponding significance level. The results strongly support the conclusion that a long-run relationship between the two variables does exist.

The results of Granger causality between coal consumption and real GDP, as well as the computed F values and their respective probabilities for the data of those series during the period 1980-2010 with specific lag period, as calculated through equations (2)and (3), are presented in Table 3.

Table 3: Granger Causality Test

Null Hypothesis	Obs	Number o Lags	F-Statistic	P-value
COLC does not Granger Cause RGDP	28	1	1.81238	0.18582
RGDP does not Granger Cause COLC	28	1	4.7381	0.03058

Source: author's calculation using EVIEWS

The results presented in Table 3 provide convincing evidence of a unidirectional causality running from economic growth proxied by RGDP to coal consumption. We therefore, reject the hypothesis that real GDP does not Granger cause electricity consumption and conclude that real GDP actually affects coal consumption.

Conclusion

This study examines the relationship between coal consumption and economic growth using Nigeria's data from 1980-2010. To achieve the objectives, the study utilised the two-step residual-based approach to cointegration and also the Granger causality test . Additionally, ADF unit root tests is utilised to affirm the order of integration for each series and also to ensure the robustness of the results. The empirical results of this study reveal that coal consumption and economic growth in Nigeria are moving together in the long run. Also, the causality results indicate a unidirectional relationship running from economic growth to coal consumption. This means that continuous economic growth simultaneously generates a continuous rise in coal consumption. In this case, coal consumption is fundamentally driven by real GDP. The findings of this contribution imply some policy recommendations. Since economic growth directly causes coal consumption and not vice versa, the closure or slow down of coal consumption in Nigeria should not have, in general, a significant negative impact on Nigerian economy. In other words our major finding supports the conservation hypothesis of coal consumption with respect to economic growth in Nigeria. Finally, further research is needed to extend this analysis to other multivariate systems, where coal consumption and GDP are exposed to be determined by other economic factors such as price, employment and exports.

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Appendix

ADF Test Statistic	2.016776	1% Critical Value*	-3.6852
		5% Critical Value	-2.9705
		10% Critical Value	-2.6242

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RGDP)
Method: Least Squares
Date: 10/28/11 Time: 03:15
Sample(adjusted): 1982 2009
Included observations: 28 after adjusting endpoints

Variable	Coefficien	Std. Error	t-Statistic	Prob.
RGDP(-1)	0.049094	0.024343	2.016776	0.0546
D(RGDP(-1))	-0.022971	0.027520	-0.834681	0.4118

C	-0.572937	0.308006	-1.860148	0.0747

R-squared	0.173646	Mean dependent var	0.044675
Adjusted R-squared	0.107538	S.D. dependent var	0.052513
S.E. of regression	0.049609	Akaike info criterion	-3.068331
Sum squared resid	0.061526	Schwarz criterion	-2.925594
Log likelihood	45.95663	F-statistic	2.626688
Durbin-Watson stat	1.379680	Prob(F-statistic)	0.092167

ADF Test Statistic	-3.940960	1% Critical Value*	-3.6959
		5% Critical Value	-2.9750
		10% Critical Value	-2.6265

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(RGDP,2)

Method: Least Squares

Date: 10/28/11 Time: 03:16

Sample(adjusted): 1983 2009

Included observations: 27 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(RGDP(-1))	-0.666827	0.169204	-3.940960	0.0006
D(RGDP(-1),2)	0.052109	0.024389	2.136565	0.0430
C	0.036204	0.011658	3.105652	0.0048

R-squared	0.404386	Mean dependent var	0.003400
Adjusted R-squared	0.354752	S.D. dependent var	0.054047
S.E. of regression	0.043415	Akaike info criterion	-3.331603
Sum squared resid	0.045236	Schwarz criterion	-3.187621
Log likelihood	47.97664	F-statistic	8.147292
Durbin-Watson stat	2.135185	Prob(F-statistic)	0.001993

ADF Test Statistic	-1.733176	1% Critical Value*	-3.6752
		5% Critical Value	-2.9665
		10% Critical Value	-2.6220

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(COLC)
Method: Least Squares
Date: 10/28/11 Time: 03:17
Sample(adjusted): 1982 2010
Included observations: 29 after adjusting endpoints

Variable	Coefficient	Std. Error	t-Statistic	Prob.
COLC(-1)	-0.238321	0.137505	-1.733176	0.0949
D(COLC(-1))	-0.152352	0.189455	-0.804156	0.4286
C	0.706428	0.498347	1.417543	0.1682
R-squared	0.164826	Mean dependent var	-0.092606	
Adjusted R-squared	0.100582	S.D. dependent var	0.810963	
S.E. of regression	0.769099	Akaike info criterion	2.410502	
Sum squared resid	15.37933	Schwarz criterion	2.551946	
Log likelihood	-31.95228	F-statistic	2.565623	
Durbin-Watson stat	2.163346	Prob(F-statistic)	0.096183	

ADF Test Statistic	-8.153546	1% Critical Value*	-3.6852
		5% Critical Value	-2.9705
		10% Critical Value	-2.6242

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(COLC,2)

Method: Least Squares

Date: 10/28/11 Time: 03:18

Sample(adjusted): 1983 2010

Included observations: 28 after adjusting endpoints

Variable	Coefficien	Std. Error	t-Statistic	Prob.
D(COLC(-1))	-2.027094	0.248615	-8.153546	0.0000
D(COLC(-1),2)	0.598737	0.156441	3.827252	0.0008
C	-0.172726	0.125041	-1.381354	0.1794

R-squared	0.773459	Mean dependent var	0.024218
Adjusted R-squared	0.755335	S.D. dependent var	1.312008
S.E. of regression	0.648966	Akaike info criterion	2.074085
Sum squared resid	10.52893	Schwarz criterion	2.216821
Log likelihood	-26.03719	F-statistic	42.67758
Durbin-Watson stat	2.184106	Prob(F-statistic)	0.000000

Dependent Variable: RGDP

Method: Least Squares

Date: 10/28/11 Time: 02:55

Sample(adjusted): 1980 2009

Included observations: 30 after adjusting endpoints

Variable	Coefficien	Std. Error	t-Statistic	Prob.
C	13.89315	0.239291	58.05972	0.0000
COLC	-0.375847	0.065332	-5.752857	0.0000
R-squared	0.541700	Mean dependent var		12.58402
Adjusted R-squared	0.525332	S.D. dependent var		0.588285
S.E. of regression	0.405305	Akaike info criterion		1.095989
Sum squared resid	4.599630	Schwarz criterion		1.189402
Log likelihood	-14.43983	F-statistic		33.09536
Durbin-Watson stat	1.276912	Prob(F-statistic)		0.000004
ADF Test Statistic	-3.089202	1% Critical Value*		-3.6852
		5% Critical Value		-2.9705
		10% Critical Value		-2.6242

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation

Dependent Variable: D(STATRESID)

Method: Least Squares

Date: 10/28/11 Time: 03:13

Sample(adjusted): 1982 2009

Included observations: 28 after adjusting endpoints

Variable	Coefficien	Std. Error	t-Statistic	Prob.
STATRESID(-1)	-0.714094	0.231158	-3.089202	0.0049
D(STATRESID(-1))	0.014466	0.136258	0.106167	0.9163
C	0.036433	0.053365	0.682710	0.5011
R-squared	0.336394	Mean dependent var		0.008627
Adjusted R-squared	0.283306	S.D. dependent var		0.328411
S.E. of regression	0.278026	Akaike info criterion		0.378750
Sum squared resid	1.932455	Schwarz criterion		0.521486
Log likelihood	-2.302495	F-statistic		6.336484
Durbin-Watson stat	1.795691	Prob(F-statistic)		0.005941

Pairwise Granger Causality Tests

Date: 10/28/11 Time: 03:21

Sample: 1980 2010

Lags: 2

Null Hypothesis:	Obs	F-Statistic	Probability
COLC does not Granger Cause RGDP	28	1.81238	0.18582
RGDP does not Granger Cause COLC		4.07381	0.03058