An Autoregressive Distributed Lag (ARDL) Approach to the Oil Consumption and Growth Nexus: Nigerian Evidence

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Abstract

This study attempted to examine the relationship between oil consumption, carbon emission and economic growth in Nigeria covering the period 1980-2011. The study applied Dickey-Fuller Generalised Least Square (DF-GLS) unit root test and autoregressive distributed lag (ARDL) bound test approach to co-integration. The bond test results revealed a long-run equilibrium relationship among oil consumption, carbon emission and economic growth. The result also showed a positive and statistically significant impact of oil consumption on economic growth. The coefficient of error correction term in the ARDL model was statistically significant, indicating that the adjustment process by which long-run equilibrium is restored after a shock is very fast. In conclusion, oil consumption played an important role in the economic growth of Nigeria, thus efforts to conserve oil will have a negative repercussions on economic growth. Therefore, Nigeria should endeavour to overcome the

Keywords: Oil consumption, Economic growth, ARDL, Nigeria

I. Introduction

Oil serves as one of the critical factor in promoting and sustaining economic growth. Despite Nigeria's proven reserve of crude oil of 37.2 billion barrels as at the end of 2010, the tenth largest in the world and the second largest in Africa behind Libya, the largest amount of that consumed is imported (Sambo, 2010). It is worth noting that the share of oil in total export value rose from less than 1 per cent in 1958 to a peak of 97 per cent in 1984 and has not been less than 90 per cent since then. In the first half of 1990, it accounted for over 95 per cent of total exports and its share of GDP had ranged between 25 and 30 per cent in recent years.

However, the linkage of carbon emission and growth is also closely related to the

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relationship between oil consumption and carbon emission as combating oil use will, on one hand, reduce the level of emission and on the other might affect economic growth in a negative manner (Ozturk and Uddin, 2012). With the recent rapid industrialisation, increased population and significant change in life style, the threat of global warming, climate change and environmental degradation particularly the unprecedented increase in CO_2 emissions (Nwosa, 2013) became visible. It is, therefore, important to examine the relationship among oil consumption, CO_2 emissions and economic growth by bringing out the policy implications on the economy.

Unlike the previous studies conducted on the relationship between energy consumption and economic growth in Nigeria (e.g., Ebohon, 1996: Odularo, 2008; Olusegun, 2008; Omotor, 2008; Odularo and Okonkwo, 2009; Dantama, Zakari, and Inuwa, 2012; Dantama and Inuwa, 2012; Olumuyiwa, 2012; Nwosa, 2013; and Olufemi and Olalekan, 2013), the relationship between oil consumption and economic growth has not been deeply examined.

To the best of the authors' knowledge, no study that focuses on the relationship between oil consumption and economic growth with respect to Nigeria has been carried out. Thus, the purpose of this paper is to examine the effect of oil consumption and CO_2 emissions on economic growth and to also suggest appropriate policy recommendation. The rest of the paper is organised as follows. Section 2 presents the brief literature review whereas, Section 3 discusses the nature of the data and the proposed econometric methods adopted. Section 4 presents the empirical results, while the last Section concludes the paper.

II. Literature Review and Theoretical Framework

It is worth-noting that mainstream economic theories do not explicitly specified a relationship among energy consumption, CO_2 emissions, and economic growth. A number of studies have examined the relationship between energy consumption and economic growth, between environmental pollution and economic growth and their policy implications (Tiwari, 2011). This line of research focuses on the

Environmental Kuznets Curve (EKC) or what is also termed the Carbon Kuznets Curve (CKC) hypothesis. The higher economic growth rates pursued by developing countries, the greater the consumption of an increasing quantity of commercial energy, which comes at the cost of ignoring technologies that are more efficient. Thus, there is controversy as to whether energy consumption is a stimulating factor, or is itself a result of economic growth. The increased share of CO_2 emissions in the atmosphere that is a product of the unbridled use of fossil fuels has negative impacts on natural systems (Tiwari, 2011).

However, empirical studies were conducted to examine the relationship between oil consumption, carbon emissions and economic growth. Zou and Chau (2006),Yoo (2006), Aktas and Yilmaz (2008), Bhusal (2010); and Farooq and Ullah (2011) applied Johansen maximum likelihood co-integration technique and error correction model to study the short- and long-run relationships between oil consumption and economic growth for China, Korea, Turkey, Nepal and Pakistan, respectively. The estimation results revealed a bi-directional causal short and long-run equilibrium relationship between oil consumption and economic growth. Other studies by Park and Yoo (2013), Yazdan and Hossein (2013) and Lim, Lim, and Yoo (2014) also applied the Johansen maximum likelihood co-integration test technique and Granger causality test based vector error correction model (VECM) to study causal relationship between oil consumption and economic growth for Malaysia, Iran and Philippines, respectively. The studies concluded that a long-run equilibrium relationship existed between oil consumption and economic growth. The short-run causality revealed bidirectional causality between oil consumption and economic growth. The long-run causality results further revealed bidirectional causality between oil consumption and economic growth. A similar study by Stambuli (2014) for Tanzania during the period 1972-2010 revealed a long-run equilibrium relationship between oil consumption, oil prices, and economic growth. The Granger causality test revealed a unidirectional causality running from oil consumption to oil prices, and from economic growth to oil consumption. The results therefore justified conservation hypothesis.

Using autoregressive distributed lag (ARDL) bounds test, Fuinhas and Marques (2012) examined the relationship between oil consumption and economic growth in Portugal during the period 1965-2009. The results established a long-run equilibrium relationship between oil consumption and economic growth. It further revealed bidirectional causality between oil consumption and economic growth in both the short-run and long-run.

However, on the basis of panel data, Narayan and Wong (2009) applied panel co-integration developed by Pedroni and Panel Granger causality test to identify the determinants of oil consumption for 6 Australian states and Territory over the period 1985-2006. The results showed the existence of long-run relationship among oil consumption, oil prices, and income. Further, oil prices had positive but statistically insignificant impact on oil consumption, while income had a positive and significant effect on oil consumption; meaning that 1 per cent increase in per capita income would lead to an increase in per capita oil consumption by 0.2 per cent. The causality test results suggested unidirectional causality running from income to both oil prices and oil consumption in both the short-and long-run. Similarly, Pourhosseingholi (2013) applied Pedroni panel co-integration technique, full modified ordinary least square (FMOLS) and Granger causality test based on vector error correction model (VECM) to examine the causal relationship between oil consumption and economic growth for the OPEC member countries during the period 1980-2011. The study concluded that a long-run equilibrium relationship existed between oil consumption and economic growth while the Granger causality test results presented a bi-directional causality between oil consumption and economic growth.

Al-mulali (2011) applied Engle and Granger, Kao co-integration techniques and panel Granger causality test to investigate the impact of oil consumption on economic growth for MENA countries over the period 1980-2011. The results showed that CO_2 emission and oil consumption had long-run equilibrium relationship with economic growth. Furthermore, Granger causality test results reveal bidirectional causality between oil consumption, CO_2 emission and economic growth in both short and long-run.

Behmiri and Manso (2012) applied Engle-Granger two-stage co-integration technique and panel Granger causality tests to investigate the long-run and causal relationships between crude oil consumption and economic growth, covering the period 1976-2009 for 27 OECD countries. The results suggested the existence of long-run relationships among crude oil consumption, crude oil price and GDP proxied for economic growth. The panel Granger causality results showed two-way relationships for both short- and long-run, thereby disputing crude oil conservation hypothesis as any increase or decrease in crude oil consumption would adversely affect the economic growth of the OECD countries.

Another recent study by Chu (2012) employed Bootstrap panel Granger Causality test to study the direction of causality between oil consumption and economic growth for 49 countries over the period 1970-2010. The results were classified into growth, conservation, neutrality and feedback hypotheses. The direction of causality between oil consumption and output justified neutrality hypothesis for 24 countries, growth hypothesis for 5 countries, conservation hypothesis for 13 countries as well as feedback hypothesis for 7 countries.

However, using a cross-country study of 42 countries to compare oil consumption and economic efficiency of advanced, developing and emerging economies, Halkos and Tzeremes (2011) applied Data Envelopment Analysis (DEA) and generalised method of moments (GMM) over the period 1986-2006. The findings showed that advanced economies had much higher turning points compared to developing and emerging economies. Moreover, oil consumption increased economic efficiency for all the countries. Finally, the GMM estimates revealed the presence of an inverted U-shaped relationship between countries economic efficiency and oil consumption, with statistically significant estimates.

Ozturk and Uddin (2012) applied Johansen maximum likelihood test approach to co-integration and Granger causality based on vector error correction model

(VECM) to investigate the causal relationship between energy consumption, carbon emissions and economic growth for India during the period 1971-2007. The results showed bidirectional causality between energy consumption and economic growth. Also, there was unidirectional causality running from energy consumption to carbon emission.

III. Methodology

III.1 Data

The data used consisted of annual time series of Real Gross Domestic Product (RGDP), oil consumption and CO_2 emissions for Nigeria 1980 to 2011. The data on RGDP was obtained from the Central Bank of Nigeria Statistical Bulletin, while data on oil consumption were obtained from the International Energy Statistics and data on CO_2 emissions were obtained from World Development Indicators (2013). RGDP was used as proxy for economic growth, following the work of Zou and Chau (2006), Oil consumption was used as petroleum consumption. It was expressed as thousands of barrels per day as done by Yoo (2013) and Fuinhas and Marques (2013). A carbon dioxide emission was employed as those emissions stemming from the burning of fossil fuels and the manufacture of cement. The choice of this variable was justified as done by Lim, Lim and Yoo (2014) and Ozturk and Uddin (2012).

III.2 Unit Root Test

The ARDL bounds testing approach to co-integration can be applied irrespective of whether the variables are I(0), I(1) or fractionally co-integrated. However, in the presence of I(2) variables the computed F-statistics provided by Pesaran, Shin, and Smith (2001) become invalid. This is because the bounds test is based on the assumption that the variables should be I(0) or I(1). Therefore, the implementation of unit root tests in the ARDL procedure is necessary to ensure that none of the variables is integrated of order two i.e. I(2) or beyond. For this purpose, the study uses the conventional DF-GLS unit root tests.

III.3 Co-integration Test

Autoregressive Distributed Lag (ARDL) bounds testing approach to co-integration has been applied to examine long-run equilibrium relationship between the variables. An ARDL model is a general dynamic speci?cation, which uses the lags of the dependent variable and the lagged and contemporaneous values of the independent variables, through which the short-run and the long-run equilibrium relationship can be estimated. ARDL technique involves estimating the following unrestricted error correction model:

$$\Delta \ln RGDP_t = \alpha_0 + \alpha_1 \ln RGDP_{t-1} + \alpha_2 \ln OILC_{t-1} + \alpha_3 \ln COEM_{t-1} + \sum_{i=1}^{q} \alpha_{4i} \Delta \ln RGDP_{t-i} + \sum_{i=0}^{p} \alpha_{5i} \Delta \ln OILC_{t-i} + \sum_{i=0}^{r} \alpha_{6i} \Delta \ln COEM_{t-i} + \mu_{t1} \quad (1)$$

$$\Delta \ln OILC_t = \beta_0 + \beta_1 \ln OILC_{t-1} + \beta_2 \ln RGDP_{t-1} + \beta_3 \ln COEM_{t-1} + \sum_{i=1}^{q} \beta_{4i} \Delta \ln OILC_{t-i} + \sum_{i=0}^{p} \beta_{5i} \Delta \ln RGDP_{t-i} + \sum_{i=0}^{r} \beta_{6i} \Delta \ln COEM_{t-i} + \mu_{t2} \quad (2)$$

$$\Delta \ln COEM_t = \delta_0 + \delta_1 \ln COEM_{t-1} + \delta_2 \ln RGDP_{t-1} + \delta_3 \ln OILC_{t-1} + \sum_{i=0}^{q} \delta_{4i} \Delta \ln COEM_{t-i} + \sum_{i=0}^{p} \delta_{5i} \Delta \ln RGDP_{t-i} + \sum_{i=1}^{r} \delta_{6i} \Delta \ln OILC_{t-i} + \mu_{t3} \quad (3)$$

From equation (1) through (3), ? represents the difference notation, while lnRGDP, lnOILC and lnCOEM are the natural logarithm of RGDP, oil consumption and CO_2 emissions, respectively. The null hypothesis for each of the equation is:

H_0: $\alpha_1 = \alpha_2 = \alpha_3 = 0$, H_1: $\alpha_1 \neq \alpha_2 \neq \alpha_3 \neq 0$
H_0: $\beta_1 = \beta_2 = \beta_3 = 0$ H_1: $\beta_1 \neq \beta_2 \neq \beta_3 \neq 0$
H_0: $\delta_1 = \delta_2 = \delta_3 = 0$ $H_1 \neq \delta_1 \neq \delta_2 \neq \delta_3 \neq 0$

From Eqs. (1)–(3), the F-test can be used to examine whether a long-run equilibrium relationship exists between the variables or not, by testing the signi?cance of the lagged level variable. The computed F-statistics for co-integration are denoted as F_{RGDP}(RGDP/OILC,COEM), F_{OILC}(OILC/RGDP,CEOM), and F_{CEOM}(COEM/RGDP OILC)for each equation, respectively. Pesaran, Shin and Smith (2001) tabulated two sets of critical values. The ?rst set of critical values is called lower-bounds critical values, and the second set of critical values is known as upper bounds critical values. According to Pesaran, Shin, and Smith (2001), the null hypothesis of no co-integration is rejected if the calculated F-statistic is more than the upper-bound critical values. On the other hand, if the calculated F-statistic is less than the lower-bound critical values, we cannot reject the null hypothesis, and hence the variables are not co-integrated. Finally, the decision about co-integration is inconclusive if the calculated F-statistic falls between the lower and upper-bound critical values.

IV. Empirical Results

This section consists preliminary analyses (where results of the of unit root tests and co-integration tests are presented and discussed); estimation results (where the regression results are presented and discussed); and post-estimation analysis (where the model diagnostics are presented and discussed).

IV.1 Preliminary Analyses

The results of the unit root test are presented in Table 1. The DF-GLS test results indicate that all the variables; i.e. RGDP, oil consumption, and CO_2 emissions, are stationary after first differencing. Thus, the necessary condition for the application of the bounds test is justified.

Table 1 Unit Root Tests

Variable	DF-GLS test at Level	DF-GLS at first Difference
RGDP	-0.225930	-2.246696**
OILC	-1.362379	-4.487645***
COEM	-1.276135	-4.933902***

***Source*:** authors' computations ***and** indicates level of significance at 1per cent and 5per cent

IV.2 Estimation Results

The results of the bounds test approach to co-integration are reported in Table 2. The bounds test indicated that co-integration was only present when RGDP was the dependent variable. This was because F_{RGDP} (RGDP/OILC, COEM) was 6.1294 higher than the upper bound critical value at the 5per cent critical value. However, the bounds test indicated that the test was inclusive when OILC was taken as dependent variable because F_{OILC} (OILC/RGDP, COEM) fell within the lower and upper bound critical value. As for COEM as dependent variable, the F_{COEM}(COEM/RGDP, OILC,) was lower than the lower bound critical value at the 5 per cent level. Therefore, there was co-integration when Real GDP was treated as the dependent variable.

Table 2: Bounds Test Results

F-Statistic	Critical Values at 5per cent	Lower bound	Upper bound
F_{RGDP} (RGDP/OILC,COEM)	=6.1294	2.9666	4.2347
F_{OILC} (OILC/RGDP,COEM)	=4.0594		
F_{COEM} (COEM/RGDP,OILC)	=1.0528		

Source: authors' computations.

The results of the estimated long-run coefficients were presented in Table 3. The estimated coefficients of the long-run relationship showed that oil consumption has a positive and significant impact on real GDP; a proxy for economic growth. Therefore, a unit increase in oil consumption led to approximately 1.98 unit increase in real GDP in Nigeria. However, the coefficient of CO_2 emissions was not significant.

Table 3: Results of Estimated Long-run Coefficients

Regressor	Coefficient	Standard error	T-ratio [p-value]
Dependent variable; RGDP			
OILC	1.9784	.011481	172.3301[.000]
COEM	-.22164	.21095	-1.0507[.303]

Source: authors' computations.

The results of the short-run dynamic coefficients associated with the long-run relationship obtained from the ECM equation were reported in Table 4. The sign of the short-run dynamic impact was maintained to the long-run. The error correction coefficient estimated at -0.12832 (0.002) was highly significant; it had the correct sign and implied a high speed of adjustment to equilibrium after a shock. Approximately 12.8 per cent of disequilibria from the previous year's shock was restored in the current year.

Table 4: Error Correction Representation for the Selected ARDL Model

Regressor	Coefficient	Standard error	T-ratio [p-value]
Dependent variable:			
?RGDP			
?OILC	.25388	.073960	3.4326 [.002]
?CEOM	-.028441	.024283	-1.1713[.252]
ECM (-1)	-.12832	.037532	-3.4190[.002]

Source: authors' computations.

IV.3 Post-estimation Analysis

Table 5 presented diagnostics test of the estimated ARDL model. The model passed all diagnostic tests. There was no evidence of serial correlation and the model was well specified, based on their probability values. Similarly, the battery of diagnostic tests for heteroscedasticity and normality of the residuals, did not find any signi?cant evidence of departures from standard assumptions.

Table 5: Diagnostics Test

Test Statistics	LM test
Serial Correlation	CHSQ(1) =1.8068[.179]
Functional Form	CHSQ(1) =0.021169[.884]
Normality	CHSQ(2) =0 .80823[.668]
Heteroscedasticity	CHSQ(1) =0 .89441[.344]

Source: authors' computation.

V. Conclusion

This study examined the relationship among oil consumption, CO_2 emissions, and economic growth in Nigeria during the period 1980–2011 using autoregressive distributed lag (ARDL) bounds testing approach to co-integration. Empirical results showed that there was long-run equilibrium relationship among oil consumption, CO_2 emissions, and economic growth. Also, oil consumption had positive and statistically significant impact on economic growth. Furthermore, the coefficient of error correction term in the ARDL model was statistically significant and was correctly signed.

Thus, oil consumption could be considered as one of the leading determinants of economic growth in the short-run as well as in the long-run. The basic premise for this may be that the enormous use of oil, mostly in the industry sector, had directly pushed the economy. Therefore, policy makers in Nigeria should take into account that implementing oil conservation policies will affect economic growth negatively since it has been found to have positive impact on economic growth.

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