26

Disaggregated Analysis of Energy Consumption and Economic Performance in Nigeria

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Abstract

The study develops a comprehensive disaggregated analysis of energy consumption and economic performance with the aim of explaining and providing a long-term solution to inconsistent growth-energy problem experienced in the country. Following Solow (1957) and Odularu (2009), the study specifies a model which expresses real gross domestic product as a function of the components of total energy consumption,namely, coal, oil and gas consumption. Augmented Dickey Fuller (ADF) Unit root test was carried out and the results are presented. The Engel-Granger two-stage error term was used for co-integration. The coefficient of the ECM is well behaved and significant, and the speed of adjustment is high. On the basis of a priori expectation, the entire variables have their theoretical signs on the current periods, except lag of gross fixed capital formation, as well as consumption at first and second lags. The models are subjected to series of policy simulations to evaluate the various options for government to improve the productive capacity of the economy, thereby achieving sustained accelerated growth.

Introduction

Since the 1970s, the energy crisis and the continuous increase in energy prices, especially oil prices, have had an impact on the economic activities of several developing nations. The reason, of course, is not far to seek: energy is an indispensable force driving all economic activities, that is, the greater the energy consumption, the more the economic activities in the country (Gbadebo, Odularu and Okonkwo, 2009). Literature abounds on the impact of energy consumption and economic growth (Gbadebo, Odularu and Okonkwo 2009; Soile, 2011). Despite the usefulness of energy, the question on which energy consumption promotes economic growth is still open to debate. Nigeria, being richly endowed with natural resources, including potential energy resource, is seen globally as one of the developing nations with great prospect in Africa. However, Nigeria has not been able to meet its energy needs possibly because of its over-reliance on oil. Statistics shows that petroleum consumption as a percentage of total energy consumption has increased in the last two decades. As mentioned earlier, numerous studies on the impact of energy consumption have focused on energy consumption and growth, however, studies on the disaggregated impact of energy on growth are scanty, and this study is intended to fill part of this gap. The specific objectives of the paper are to examine the relationship between disaggregated energy component and economic performance in Nigeria and examine the sources of energy in Nigeria.

Literature Review

Nigeria is one of the developing countries of the world trying to move up from current economic condition and in this endeavour, energy consumed might play a key role. Modern energy has become essential for higher economic growth, poverty alleviation and social development. The current rate of energy consumption has been constraining the country's endeavour towards attracting sizeable foreign direct investment, promoting regional development, improving the life standards of local people, participating in the globalization process and achieving socio-economic development. Despite having the low per capita consumption, Nigeria is lucky to have substantial reserves of natural gas, oil and coal. The problem is that, the country is not skilled enough to make use of these resources. Commercial energy in Nigeria has been conquered particularly in electricity generation. Coal and gas is yet to make any significant impact in the energy scenario. Traditional fossil energy sources like crude oil are found to account for over half of the country's energy consumption. The amounts of coal and gas consumption have been relatively low. Although, Nigeria has abundant reserves of natural gas in energy terms, the quantity of natural gas is at least twice as much as crude oil, and the horizon for the availability of natural gas is definitely longer than that of oil. The known reserves of natural gas have been estimated at about 2.4 x 10^{12} m^3 and are expected to last for more than a century as a domestic fuel and a major

Nigeria has the largest natural gas reserves in Africa and is among the top ten in the world. However, due to lack of utilization and infrastructure, Nigeria still flares about [illegible] of the natural gas it produces, which accounts for about 20 per cent of all gas flared worldwide. In Nigeria, 75 per cent of the associated gas that is flared is burnt off. This wastage is due to inadequate infrastructure and the remedy therefore, is to build the infrastructure to reduce this wastage which could have been used to boost supply and revenue receipt from sellers of this energy product. Natural gas can also be converted to a liquid state known as the Liquefied Natural Gas (LNG). This is a natural gas product whose market is also constantly increasing. Natural Gas has been affirmed to be the fastest growing source of primary energy according to EIA (2004), while coal resource is [illegible].

In the past twenty years, dozens of scholars have explored the relationship between energy consumption and economic growth for different countries and over different periods using different methodologies and a broad literature has been established in this field. Kraft and Kraft (1978), Akarca and Long (1980), Erol and Yu [illegible] (1993), Masih and Masih (1997), Asafu and Adjaye (2000), Soytas, Sari and Ozdemir (2001), and Rufael (2005) are studies which have important contributions to the literature. The first study on this subject was conducted by Kraft and Kraft (1978). Initially, the relationship between USA's energy consumption and GNP for the period between 1947 and 1974 was examined; a unidirectional causality relation from GNP to energy consumption was found. After two years, Akarca and Long (1980), tested the relationship with the same data for the USA for 1947–1972 period and could not find a relationship between variables. Erol and Yu (1987) examined the relationship between energy consumption and GDP for England, France, Italy, Germany, Canada and Japan between 1952 and 1982, and the causality relationships they found were bidirectional for Japan, unidirectional from energy consumption to GDP for Canada unidirectional from GDP to energy consumption for Germany and Italy. They could not find causality for France and England. A common character of these studies is that they are bivariate models.

[illegible] claimed that causality relationship in bivariate models is not healthy because substitution effect of energy with other variables is ignored and in his study, he found the relationship between the USA's energy consumption and GDP with a multivariate co-integration model and could not find a relation-ship. Stern (2000) also found causality between energy consumption and GDP for the USA for the period between 1948 and 1994 with a multivariate model and his results supported his hypothesis. Soytas, Sari and Ozdemir (2001) examined the relationship between energy consumption and GDP for Turkey for the period between 1960 and 1995 and found unidirectional causality relationship from energy consumption to GDP for that

In the literature, besides studies which study energy as a whole, there are also studies

which examined energy by separating it into its sub-components such as electricity and petroleum. Ghosh (2002) examined economic growth and electricity consumption of India between 1950 and 1997. As a result of the study, he found a unidirectional causality relationship from economic growth to electricity consumption. Jumbe (2004) examined the relationship between electricity consumption and GDP for Malawi for the period between 1970 and 1999, and found a bidirectional causality relationship. However, when he examined the relationship between non-agriculture GDP and electricity consumption, he found a unidirectional causality relationship from GDP to energy consumption. Rufael (2006) examined the relationship between electricity consumption and GDP for 17 African countries for the period between 1971 and 2001 with limit test approach and found cointegration relationship in nine countries and Granger causality relationship for 12 countries. While the direction of causality is from GDP to electricity consumption in six of these countries and from electricity consumption to GDP in three of them; bidirectional causality was found in three countries. In the literature, there is not enough study which investigates oil consumption and GNP interaction except that of Zou and Chau (2005). Zou and Chau (2005) found no cointegration between oil consumption and GDP, in China for the period of 1953-2002. Due to liberalization of China's economy in 1984; they separated these periods into 1953-1984 and 1985-2002. They found cointegration relationship between oil consumption and GDP. In 1953-1984 periods, they found no causality between oil consumption and GDP *in the short-run; conversely, they found bidirectional causality in the long-run. In the short run from 1985-2002*, they found unidirectional causality from oil consumption to GDP, however, in the long-run, there was bidirectional causality between 1953 and 1984 period.

Glasure (2002) used a five-variable vector ECM to study the (Granger) causality between economic growth and energy consumption in South Korea. Government expenditure was used as a substitute for government activity, money supply was used as a substitute for monetary policy and prices of oil were also included as an important factor in explaining the causality. The period 1961 to 1990 was covered in the study. He provided evidence to support a bi-directional causation, and the oil price was found to have the most significant impact on GDP and energy use. Oh and Lee (2004) also studied the relationship between the variables in South Korea, but they covered the period of 1970 to 1999 in their study. They adopted a system that was more based in the classic production function literature (which was also supported by Stern (1993)). Besides energy, labour and capital were also considered to be important factors of production for generating economic growth. For quality improvements in energy, they used a mean value weighted log Divisia index to establish the level of energy consumption in the economy. Following Glasure (2002), they also used a vector ECM and provided evidence to support a bi-directional causation between energy and GDP.

Yu and Jin (1992) used employment as a third variable in establishing the long-run equilibrium relationship between energy consumption and GNP. They used monthly

the period 1974:1.1990:41 for the United States and found no evidence to support tion. With this result, they found support for initial conclusions that energy tion policies do not have adverse impacts on economic growth in the US and that servation has no clear effect on employment. Wolde and Rufael (2004) studied relationship between various kinds of industrial energy consumption and real Shanghai for 1952-1999. The empirical evidence suggested that there was a nal Granger causality running from coal, coke, electricity and total energy tion to real GDP, except oil consumption. Odularu (2009) studied the causal between various energy components and real GDP in Nigeria for 1970-2005. ical evidence suggested that there was a unidirectional Granger causality from coal, oil, and electricity consumption to real GDP.

and Karagol (2005) found a strong long-run causality running from energy tion to the real GDP in Turkey. The main conclusion of their study is that lationship of causality between the variables. Sari and Soytas (2003) studied sality running from energy consumption to income in the long-run but also a bi-directional causality in the short-run. Lise and Montfort (2007) that causality runs from income to energy consumption in the long-run. (2007) found an evidence for the income and price elasticities of the energy demand both in the short-run and long-run for Turkey over the period Bowden and Payne (2008) found a bidirectional Granger-causality causality rgy consumption and real GDP. Soytas and Sari (2007) investigated the between energy (electricity consumption) and production (Turkish ing industry) at the industry level in an emerging market, Turkey. The uni- causality runs from electricity consumption to value-added.

Chang (2007) investigated a relationship between energy consumption DP in 22 developed and 18 developing countries. They found uni-directional from real GDP to energy consumption in developing countries but, there was nal causality between energy consumption and real GDP in developed

etical Framework and Methodology

guiding this study is based on the Exogenous Growth Model propounded 986). The model suggests that capital (K), labour (L) and technological A) can significantly affect growth. In this model, new technology is the terminant for long-run growth and it is itself determined by investment in hnology. Therefore, Romar takes investment in research technology as factor in terms of the acquisition of new knowledge by rational profit firms. It is noteworthy that technological advancement (*A*) is based on nt on research technology. Technology is seen as an endogenous factor be related to energy. Most technology as given per time is dependent on the

availability of useful energy to power it. The technology referred to here is that such as plants, machinery and the like. Without adequate energy supply (in this case electricity or petroleum), then this technology is practically useless. The law of thermodynamics helps to justify this by stating that 'no production process can be driven without energy conversion'.

Energy is not the sole determinant of technology but is a necessary factor to ensure that technology at whatever level is being utilized. Conversion of energy in its raw state into useful state is highly technology-oriented. Taking cue from the technology-oriented nature of energy production; it is also known that energy production is capital intensive. Huge machineries are required to produce useable energy. This will mean that huge amount of capital will be required to produce energy. Huge investments must then be made on energy not only to produce but to attain energy efficiency.

Following the theoretical framework above and the study by Odularu (2009), we specify a regression model which expresses output to capital, labour and total energy consumption. Thus, the model for this study is specified in functional form as follows:

$$Y_t = F(K_t, L_t, E_t) \quad (1)$$

Where Y_t = output at time t, K_t = capital at time t, L_t = labour force at time t, and E = total energy consumption at time t.

However, in Nigeria, total energy consumption can be disaggregated into oil consumption, coal consumption and gas consumption. Thus, replacing total energy consumption (E) with its component in equation 1, it becomes:

$$Y_t = F(K_t, L_t, GCON_t, CCON_t, OCON_t) \quad (2)$$

Where Y_t K_t and L_t remain as defined above and $GCON_t$ = gas consumption at time t, $CCON_t$ = coal consumption at time t, and $OCON_t$ = oil consumption at time t. Equation above can be re-specified in regression form as:

$$Y_t = \beta_1 + \beta_2 K_t + \beta_3 L_t + \beta_4 GCON_t + \beta_5 CCON_t + \beta_6 OCON_t + \mu_t \quad (3)$$

On a priori expectation, we expect $\beta_2 - \beta_6 > 0$, $\beta_2 - \beta_6$ represent various slope coefficient, β_1 is the constant term and μ_t is the stochastic disturbance term. Before estimating the models, the dependent variable and independent variables are separately subjected to some stationarity tests using the unit root test since the assumptions for the classical regression model require that both variables be stationary and that the errors have a zero mean and constant variance. The unit root test is evaluated using the Augmented Dickey-Fuller test which can be determined as:

$$\Delta Y_t = \alpha + \beta\tau + \delta Y_{t-1} + \sum_{t=1}^{m} \Delta Y_{t-1} + \varepsilon_t \quad (4)$$

Where α represents the drift, t represents deterministic trend and m is a lag length enough to ensure that ε is a white noise process. If the variables are integrated of order one I (1), we test for the possibility of a co-integrated relationship using the Engle and Granger (1987) two-stage error correction modelling technique. The study employed the error correction model (ECM) because it is an appropriate estimation technique that captures the short-run and long-run effect of the differenced variables. It connects the short-run and the long-run behaviour of the dependent and independent variables. The supposed long-run equation in this study is specified in Equation 3 above. Hence, the error correction model used in this study is specified as:

$$\Delta L = \beta_1 + \beta_2 \sum_{t=1}^{n} \Delta L_{t-1} \beta_4 \sum_{t=1}^{n} \Delta GCON_{t-1} + \beta_5 \sum_{t=1}^{n} \Delta OCON_{t-1} + \beta_6 \sum_{t=1}^{n} CCON_{t-1} + \delta_1 ECM(-1) + \varepsilon_t \quad (5)$$

Where L, GCON, OCON, CCON remain as defined above. The short-run effects are captured through the individual coefficients of the differenced terms. That is β_i captures the short-run impact while the coefficient of the ECM variables contains information about whether the past values of variables affect the current values of the variables under study. The size and statistical significance of the coefficient of the error correction term measures the tendency of each variable to return to equilibrium. A significant coefficient implies that past equilibrium errors play a role in determining the current outcomes, δ_1 captures the long-run impact.

The study used annual time-series data. The data of interest is output measured by gross domestic product using 1990 constant price, capital proxy with domestic investment, labour force, oil consumption, coal consumption, gas consumption. The data was sourced from Central Bank of Nigeria (CBN) Statistical Bulletin (2010).

Empirical Result and Interpretation

As a preliminary step to analysing the result, we carried out the unit root test using the Augmented Dickey Fuller (ADF) test, since research has shown that regression coefficients of non-stationary variables may lead to spurious and misleading conclusion. The results of the unit root test are presented in Table 26.1.

Table 26.1 reports the results of the stationarity tests in the level as well as in first difference for all the variables. Included in these tests are a constant and trend terms. The optimal lag length of each case for ADF tests is chosen using the Akaike Information Criteria (AIC) after testing for higher order serial correlation residuals. As shown in

Table 26.1, the statistics for all variables, we can accept the hypothesis that the series contain a unit root in the process. However, after taking the first difference, each series appeared to have stationarity with the ADF test. Since the data appeared to be stationary in first difference, no further tests were performed. Consequently, the series of GDP and those associated with categories of energy consumption were all I (1) process. Thus, the co-integration test was carried out using Engle and granger two-stage technique; this is presented in Table 26.2.

Table 26.1. Result of ADF Unit Root Test.

Variables	ADF	
	Level	First difference
LOGGCFC	-3.0397	-4.90957*
LOGLF	-0.3458	- 3.7166*
LOGRGDP	-2.3193	-5.1131*
LOGGCON	-3.4132	-7.1827*
LOGCCON	-3.2792	-5.9798*
LOGOCON	-2.9021	-5.6150*
5% Critical value	-3.5279	-3.5312*

Note: Test statistics indicate stationarity at the 5% level (*)
Source: Authors result using E-views 7

Table 26.2. Engle and Granger Co-integration Test

Variable	ADF	
	Level	Critical value
ECM	-3.0284*	-2.9499

Note: Test statistics indicates stationarity at the 5% level (*)

Source: Authors result using E-views 7

The co-integration result is presented in Table 26.2. As shown in the Table, the null hypothesis of no co-integration is rejected as the Augmented Dickey Fuller (ADF) value is more negative than the Augmented Dickey Fuller (ADF) critical value. The implication of this is that some stable long-run equilibrium relationship exists among the series, which could be given some error correction representations (Engle and Granger, 1987). It also shows that the possibility of the estimated relationship being spurious is ruled out.

26.3. Estimated Short-run Result with LOGRGDP as Dependent Variable

ssors	Co-efficient	Standard error	T-stat	P- Value
	2.8294	0.6506	4.3492	0.0005
GCCON	0.1390	0.0947	1.4681	0.1615
GGCON	0.0880	0.0679	1.2962	0.2133
GGFCF	0.2178	0.2447	0.8902	0.3865
GLF	4.5640	10.8755	0.4197	0.6803
GOCON	1.5350	0.4140	3.70759	0.0019
GCCON(-2)	-0.3253	0.1341	-2.4252	0.0275
GCCON(-1)	-0.1586	0.1142	-1.3881	0.1841
GGCFC(-3)	0.2107	0.2223	0.9478	0.3573
GOCON(-2)	0.7433	0.4921	1.5105	0.1504
GOCON(-1)	0.3014	0.4449	0.6775	0.5078
GLF(-2)	-0.7113	46.8719	-0.0152	0.9881
GLF(-1)	-60.8014	46.7060	-1.3018	0.2114
GGCON(-1)	-0.1903	0.1003	-1.8969	0.0760
GGCON(-2)	-0.1321	0.0521	-2.5341	0.0221
(-1)	-0.9210	0.1956	4.7092	0.0002
ared	0.8025			
Squared	0.6174			
	4.33 prob (F-statistic = 0.00295)			
	2.29			
istic				
gression	0.234			

Authors result using Eviews 7

The result of the parsimonious error correction model shown in Table 26.3 indicates only four variables current logocon, dlogccon (-2), dloggcon at first and second lag ed in explaining economic activities in Nigeria although at either 5 or 10 per cent The model captured the lagged changes in the independent variables. Specifically, the result obtained, the current period coefficients of three of the variables is ely related to economic activity as proxy with real gross domestic product, while oil consumption and coal consumption are inversely related with the level of

economic activity. However, none of the variables except oil consumption is significant at 5 per cent level. With the exception of second period lag of coal consumption and first and second period lags of gas consumption that are significant in explaining economic activity in Nigeria, the lags of other variables are not significant. From the result, it was discovered that first and second periods lag of coal consumption, labour force, gas consumption were inversely related to the level of economic activity as proxy by real gross domestic product. An examination of the F-statistic and the adjusted R^2, suggest that the variables in the error correction model significantly explain changes in real gross domestic product at $p < 0.05$, accounting for 61 per cent of the short-run variation in the series. The coefficient of the ECM term captured the adjustment towards the long-run equilibrium. The coefficient of ECM connotes the proportion of the disequilibrium in the differenced dependent variable in one period that is corrected in the next period. The result indicates that the speed of adjustment is high, i.e., 0.92104 (92 per cent) of the error is corrected.

25.5 Policy Recommendation and Conclusion

In this study, an error correction modelling of the disaggregated impact of energy consumption on economic activities in Nigeria during the period 1970 to 2010 was examined. Following the model by Solow (1997) and Odularu (2009), the study specified a model which expressed real gross domestic product as a function of the component of total energy consumption which is coal, oil and gas consumption. The results show that the variables in the model significantly affected the dependent variable as shown by the R2 and F-statistic. The coefficient of the ECM is well behaved and significant; and the speed of adjustment is high. On the basis of a priori expectation, the entire variables have their expected signs on the current periods, however only lag of gross fixed capital formation, oil consumption at first and second lags were well behaved. Based on the result, the following policy recommendations are made:

1. *Increased energy efficiency and conservation in the country*. As revealed in this study, oil consumption contributes to economic performance, thus, an increase in the conservation of energy and efficiency will impact on growth of the economy
2. *Increased supply of energy*. From the result, current value of the component of energy has positive effect on economic performance, thus, increase in the supply of energy will increase the production of goods which will invariably increase the level of economic activity.
3. *Energy source diversification*. The Nigerian economy has been consistently dependent on oil production as a major source of energy, this has made the country to be highly vulnerable to fluctuations in the oil market. Diversification of energy sources will reduce the fluctuation that comes from oil production.

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