

ENERGY CONSUMPTION AND PRODUCTIVITY IN NIGERIA

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Abstract

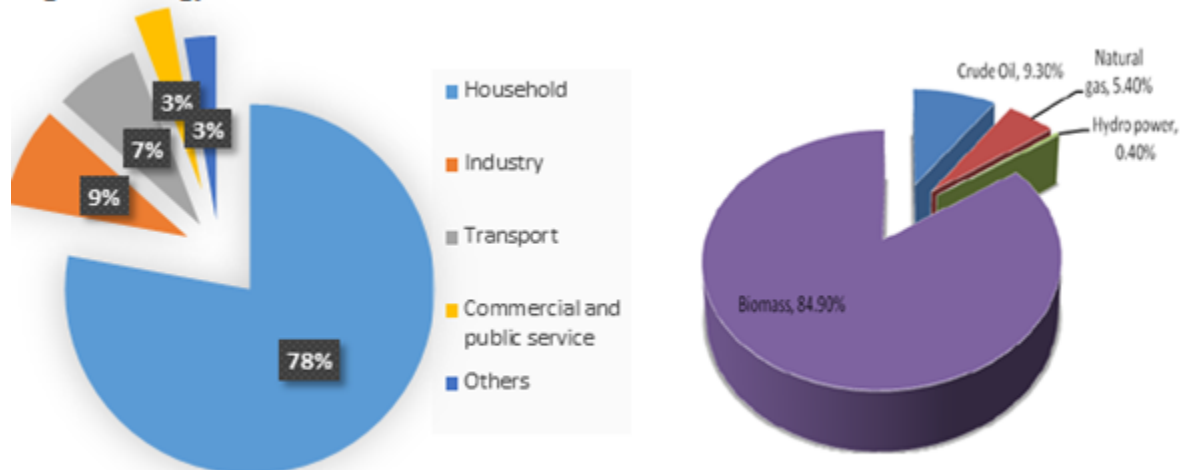
Energy is critical to the survival and expansion of any economy, but in Nigeria, energy consumption has been skewed towards household use, and below thresholds for sector driven growth. The paper updates in time and methodology those studies highlighting the significance of energy use for economic growth, using the Bound test and the Auto regression Distributed Lag (ARDL) to establish the long and short run relationships between disaggregated energy consumption and economic growth in Nigeria from 1990 to 2016. The variables considered were real GDP, energy consumption decomposed into electricity and petroleum consumption, labor and capital. The findings showed that, in the short and long run, petroleum consumption and labour have a significant positive relationship with GDP. Furthermore, the causality results showed that feedback causation between economic growth and energy consumption as well as labour exists, while one-way causation runs from labour to economic growth. The expansion and diversification of the power-generation portfolio in the country would improve energy consumption towards better output. Also, policies to encourage industrialization would move energy demand towards increasingly productive uses.

Key Word: Energy Consumption, Economic Growth, Industrialisation, Error Correction.

1.0. A historical perspective on energy consumption and economic growth in Nigeria

A sustainable energy market is such that can meet both the present and future energy demands of its economy. This is central to a thriving economy, given its role in powering the various sectors of the economy (Chukwueyem *et al*, 2014). The Nigerian energy market is dominated by the petroleum and power industry. The household sector is the highest determinant of its energy demand, as it accounts for more than 70 per cent of the country's energy consumption. Other sectors, namely, industry, transport, commercial and public service also have significant bearing on the country's energy demand. The unstable energy and power supply through the authorized grids in the country mean alternative energy resources such as biomass and wood fuel remain the most consumed energy resources.

Fig 1.1:Energy Demand



Source: Autours computation and data from EIA, 2015

Nigeria is blessed with various energy resources. With an estimated oil reserve of about 36.2 billion barrels, the country has the Africa largest crude oil reserve and sixth largest in the world. Proven gas reserves are close to 5,000 billion m³, while coal and lignite reserves are estimated to be 2.7 billion tons, furthermore the country's hydroelectricity sites have an estimated capacity of about 14,250 MW.

Despite Nigeria's endowment in energy resources, there has been wide disparity in the country's energy demand to the supply over the last two decades, access to energy services has been continuously challenging (Odularu and Okonkwo, 2009). The inability to realize the necessary

efficiency in the energy sector has meant a continuous fall in the supply of energy and inability to meet growing energy needs. This problem affects the growth of the two energy markets, that is, petroleum and electricity.

Concerning the crises in electricity market, the Power Holding Company of Nigeria (PHCN) and associated government agencies have variously failed to provide sufficient and reliable electricity supply to various sectors of the economy. The household sector is most affected, with majority of the populace finding it more efficient to use alternative energies such as wood fuel. Furthermore, other sectors such as industrial, manufacturing, service sector etc. invest heavily in generation facilities to complement the unreliable power supplies from the national grid. This in turn creates environmental hazards and negatively affects profitability, return on investment and productivity. The other energy crises the country is battling with in the petroleum sector includes the recurrent severe shortages in the supply of petroleum (PMS, Diesel, and Kerosene) products over the years, which is largely caused by the failing refineries, corruption and geopolitical conflicts in the Niger area.

Choji (2014) pointed out that this issue indeed has adverse effect on the country's economy, and may have contributed largely to the problem of high level of poverty, paralyzing industrial and commercial activities. The relationship between energy consumption and economic growth is complex, inconclusive, and has heated much debate in research. Adegbelemi *et al* (2013), Gbadebo and Okonkwo (2009), Antai *et al*, (2015), and Ighodaro (2010), all showed that energy consumption has positive relationship with economic growth. However when testing whether cause and effect could be implied, Aminu (2015), and Aremu (2016) found no causal relationship between energy consumption and growth in Nigeria. It is in light of the distinction between studies on the long run relationship and those on causality that this paper chooses to examine the datasets on energy consumption and economic growth for both type relationships at once. This paper focuses on the interactions of economic growth with both petroleum consumption and electricity consumption.

2.0. Energy consumption and the Nigerian economy

Images of energy-powered industrial revolutions around the globe emphasize the role of energy on economic growth. At the same time, a rapid growing labour force became an engine of industrial

growth against Malthusian predictions, while still retaining population pressures on scarce resources such as energy.

Energy remained relegated, in the earlier neoclassical growth sense, to an intermediate input into production, one that is assumed given, due to its finite non-renewable nature. The introduction of natural resources into growth framework depends on whether their sustainability is driven by technical or institutional conditions (Stern, 2004). Technical conditions include a mix between renewable and non-renewable resources, initial stock of natural resources and the elasticity of substitution between capital and various energy inputs. This is also theoretically related to demand elasticity of energy that describes the degree of substitution with other inputs into the production process.

Consequently, how energy impacts on growth depends on its use relative to other inputs into the production process. This informs part of the bulk of literature within the growth discourse, on energy efficiency and economic output. Further, energy inputs and efficiency varies by sector, enabling a sectoral discussion of energy and economic growth. Institutional conditions include market structure (competitive versus no perfect structures), property rights and values driving sustainability in the sense of non-exhaustion for future generations.

Further, a cumulative causation could be inferred between energy and economic growth as implied by the strand of literature on the determinants of energy demand. In the early study of energy demand, Pindyck (1979) examined the structure of demand for energy in the OECD and some developing countries. He reported that for both developed and developing countries, the price of energy and income has a significant effect on demand in the long run for residential, industrial and transport sectors. Implicitly, poor socio-economic conditions reduce energy consumption, which in turn deters economic growth, thus socio-economic conditions.

The idea that resources such as energy enhance growth has recurred throughout literature across time and space. Najid, *et al* (2012) examined the relationship between energy consumption and economic growth of Pakistan from 1973 to 2006. The results of ordinary least squares tests show positive relation between GDP and energy consumption in Pakistan. In studies on the Nigerian economy, Adegbemi *et al*, (2013) examined the nexus between energy consumption and Nigeria's economic growth for the period of 1975 to 2010, using cointegration and ordinary least square techniques. The study revealed that petroleum, electricity and the aggregate energy consumption

have significant and positive relationship with economic growth in Nigeria. However, gas consumption although positive, does not significantly affect economic growth. The impact of coal was negative while significant.

Through a similar technique, Gbadebo and Okonkwo (2009) in their study spanning the period 1970 to 2005, found that a positive relationship between energy consumption and economic growth. The study shows that energy efficiency in Nigeria has been on the decrease, it was stated that the major proportion of energy consumed in Nigeria is by household implying, most energy consumed are not at the industrial level, reducing its impact on economic growth.

Kraft and Kraft (1987) found a unidirectional causation running from only economic growth to consumption, they conclude that energy consumption does not influence economic activity, but the other way round. Alternatively, a unidirectional causality from energy consumption to economic growth in East and the Southern Africa Sub-region was observed (Chali and Mulugeta 2009).

Similarly, according to Basiru (2014) using panel data techniques to investigate the long-run relationship between energy consumption and GDP for a panel of 19 African countries (COMESA) based on annual data for the period, his results indicate that long-run and short-run causality is unidirectional, running from energy consumption to GDP. Similarly, Ighodaro (2010) found unidirectional causality between electricity consumption and economic growth, domestic crude oil production and economic growth as well as between gas utilization and economic growth in Nigeria. Choji (2014) investigates the causal relationship among electricity consumption; the findings show a positive relationship between electricity consumption and real GDP and the inverse between fuel price and real GDP.

Other studies on the US find no causation between energy and economic growth (Akarca and Long, 1980; Yu and Hwang 1984). Indeed, in Central and the West African sub-region, under the same study, Chali and Mulugeta (ibid.) observed causality between energy consumption and economic growth was absent. Using the Vector Auto regression Analysis, on energy consumption and economic growth spanning the period 1980 to 2011, Aminu and Aminu (2015) show that there exist no causal relationship between economic growth and energy consumption.

Antai *et al* (2015) showed that energy consumption had a bidirectional relationship with GDP growth, and directly contributed significantly to economic development in Nigeria. Orhewere *et al* (2011) also found a unidirectional causality from gas consumption to GDP in the short-run and bidirectional causality between the variable in the long-run. Although no causality was found in either direction between oil consumption and GDP in the short-run, a unidirectional causality from oil consumption to GDP is found in the long run.

While there is mostly a positive relationship between energy consumption and economic growth, the direction is largely inconsistent and mixed. Observably, the sample country matters in determining the direction of causality as well as the energy type. In Nigeria it is mostly reported that electricity, gas and oil consumption Granger cause economic growth.

This paper attempts to expand the field of literature by examining the relationship between economic growth and energy consumption, disaggregated into electric consumption and petroleum consumption. *According to the IEA (2014), electric power consumption measures the production of power plants and combined heat and power plants less transmission, distribution, and transformation losses and own use by heat and power plants. In practice total electric power consumption is equal to total net electricity generation plus electricity imports minus electricity exports minus electricity distribution losses.* A contextual discussion on petroleum is specific to this paper and is motivated by the knowledge that a significant proportion of the current energy consumption in Nigeria is at the household level which powers their transportation and electricity generation machines using petrol.

3.0. Does energy consumption affect Nigerian growth?

Neoclassical models, such as the Solow growth model, consider capital and labor as the primary factors of production but assume energy has a subsumed role. While ecological-economic theories emphasize the role of energy and take as given other classical inputs such as capital and labor (Hong *et al* 2017). It is possible to benefit from a understanding of the two frameworks, by adopting a production function approach, which incorporates capital and labor inputs as well as energy considered in a growth model. Hence we retain that energy consumption affects economic growth in Nigeria predominantly through technical conditions, or as a mix of renewable and non-renewable resources, a conceptualization close to Stern (2004).

Energy affects growth in our model through its stock, hence

$$GDP = f(A, L, K) \dots\dots\dots(1)$$

Where L is labour, K is capital, and, A is technological progress, which explains energy consumption. This energy consumption is decomposed into electric and petroleum consumption. This is to capture the dynamics in the two key energy markets (Petroleum and Power sector) and their distinct relationship with economic growth in Nigeria. The model is explicitly stated below. The level of technology, A, scales up various resource inputs into the production process, which this paper disaggregates into electricity and petroleum measured by their consumption, so that:

$$GDP_t = F(PEC_t, ELC_t, LAB_t, CAP_t) \dots\dots\dots(2)$$

$$GDP_t = \beta_0 + \sum_{t=1}^{k-1} \beta_1 PEC_t + \sum_{t=1}^{k-1} \beta_2 ELC_t + \sum_{t=1}^{k-1} \beta_3 LAB_t + \sum_{t=1}^{k-1} \beta_4 CAP_t \dots\dots\dots(3)$$

Where

GDP_t = Gross Domestic Product **ELC_t** = Electricity Consumption

PEC_t = Petroleum Consumption **LAB_t** = Labour

CAP = CAPITAL **U_t** = Error term

From the model, GDP is explained through petroleum consumption, electricity consumption, labour and capital.

The bound test and Auto regression distributed lag (ARDL) was used in estimating the short run and the long run dynamics of the model. Secondary data (from 1981 to 2016) was collected from international energy agency (IEA) and the World Bank website. Estimation on time series data demands that the series be stationary, hence, the Augmented Dickey and Fuller (1979) and Phillip Perron test was employed to test for unit root. The disparities in the order of integration found stationarity results in table 4.1, necessitates the bound testing and ARDL estimation of the model. The bound test is used to test for the long run relationship while the short run dynamics was seen through the ARDL short run estimate. Further, the Granger causality test was applied to determine the causal relationships among the variables; here we considered total energy consumption, economic growth, labour and capital.

4.0. Short and long run impact of energy consumption on the Nigerian economy

The paper proceeds with diagnostic tests for the stationarity status of the selected time series data to determine their order of integration. The two criteria applied, that is, the Augmented Dickey Fuller (ADF) and Philip Peron unit root test show that variables such as gross domestic product (GDP), petroleum consumption (PEC), electricity consumption (ELC), and Gross capital formation (CAP) are found stationary at levels, while variables such as total energy consumption (TEC), and Labour (LAB) are were found stationary after first difference.

Table 4.1: Results of Unit Root Test

Variable	Augmented Dickey Fuller (ADF)		Phillips Perron		Order of Integration
	Levels	1 st dif.	Levels	1 st dif.	
GDP	-5.51*	-10.63*	-5.50*	-20.27*	1(0)
PEC	-5.98*	-7.25*	-5.99*	-21.89*	1(0)
ELC	-5.97*	-7.84*	-6.00*	-14.64*	1(0)
TEC	-1.99	-1.52	-2.12	-9.15*	1(1)
LAB	-2.73	-9.54*	-2.58	-9.97*	1(1)
CAP	-3.32*	-11.25*	-5.32*	-14.75*	1(0)

* Denotes rejection of hypothesis at 5% significance level ** denotes rejection of hypothesis at 10% significance level

Source: Author's computation

The stationarity test depicts that the variables are not the same order of integration, hence the auto-regression distributed lag (ARDL) model is the best for the model.

Determination of the lag length is crucial for accuracy in the ARDL method. Hence we select four lags based on AIC and SC criterion. Furthermore, the cointegration bound test checked for a long run relationship in the model, this is shown in table 4.2.

Table 4.2: Bound Test

F-statistic	K
6.934525	4

Critical Value Bounds

Significance Level	Lower Bound	Upper Bound
10%	2.45	3.52
5%	2.86	4.01
2.5%	3.74	5.06

Source: Author's computation

From table 4.2 above, F-statistics (5.03) which is calculated at $k = 4$ (number of independent variable) exceeds the upper critical value at 10%, 5%, and 1% significance level respectively. Hence we reject the null hypothesis, and accept the alternative that there is a long run relationship among the variables in the model. Table 3 further reveal the long run coefficient of the models.

Table 4.3: Long Run Estimate

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable = ΔGDP				
PEC	1.20	0.46	2.59	0.01
ELC	0.19	0.25	0.75	0.46
LAB	7.44	3.41	2.18	0.04
CAP	0.37	0.25	1.47	0.15
C	-0.03	0.08	-0.35	0.73

* Denotes rejection of hypothesis at 0.05 significant level ** denote rejection of hypothesis at 0.10 significant level

Source: Author's computation

The long run estimate of the ARDL model are shown in table in table 4.3. The results revealed that Petroleum consumption (PEC) and labour (LAB) has a significant positive long run relationship with gross domestic product (GDP). While no significant long run relationship between electricity consumption and economic growth was found. The short run dynamics of the model is revealed in Table 4.4.

Table 4.4: Short Run Estimate

Variable	Coefficient	Std. Error	t-Statistic	Prob.
Dependent Variable = ΔGDP				
ECM (-1)	-1.21	0.17	-7.04	0.00
ΔPEC	1.45	0.55	2.61	0.02
ΔELC	0.23	0.31	0.74	0.46
ΔLAB	-3.91	5.03	-0.78	0.45
ΔLAB (-1)	1.21	5.00	0.24	0.81
ΔLAB (-2)	-10.82	4.79	-2.26	0.03
ΔCAP	0.16	0.22	0.73	0.48
ECM = GDP - (1.20*PEC + 0.19*ELC + 7.44*LAB + 0.37*CAP -0.03)				

Diagnostic Tests	
Serial Correlation LM Test	
R-squared : 0.659	: 2.700069(0.2592)
F-statistic : 4.723(0.001)	Heteroscedasticity Test : 15.41887(0.0801)
Normality Test(Jarque-Berra)	
Akaike info criterion : 0.590422	: 1.114(0.447)
Schwarz criterion : 1.048465	

* denote rejection of hypothesis at 0.05 significant level ** denote rejection of hypothesis at 0.10 significant level

Source: Author's computation

The short run estimates revealed in table 4.4, include the error correction estimate, found significant, followed by the short run coefficients of the explanatory variables. The result depicts that petroleum consumption (at levels) and labor (at 2 lagged period) both have a positive relationship with economic growth at 5% significance level, while both electricity and capital were found statistically insignificant.

The short and long run imply that petroleum consumption positively correlates with economic growth, while the electricity consumption has not been found significant. A possible explanation for this result is the dependence of the economy on petroleum products. Further, the inadequate electricity supply limits its contribution to output. Thus, as observed by Gbadebo and Okonkwo (2009), most of the energy consumption in Nigeria is at the household level, deterring growth. The

results also confirm that labour positively correlates with gross domestic product both in the short run and long run, pointing to the key role the household sector plays in shaping the economy. The result is consistent with Adebemi *et al*, (2013), Gbadebo and Okonkwo (2009), Antai *et al*, (2015), and Ighodaro (2010).

In the Diagnostic tests, the joint significance of the all the independent variables to the Real GDP is revealed by the F-statistics, the result shows that the explanatory variables are jointly significant to GDP. Also, the R-squared (0.73) that is the coefficient of determination shows that the independent variables cumulatively explain up to 85 per cent of the GDP equation, this implies that the RGDP model is fit and the explanatory variables are appropriately selected. To further check for the efficiency of the model, and also to ensure they are in line with the white noise assumption, residual based tests such as Breusch-Godfrey L-M test for autocorrelation, Jacqui Berra test for normality and Breusch-Pegan Godfrey test for Heteroskedasticity were conducted for the model, the serial correlation result reveals that the absence of autocorrelation among the variables, the Heteroscedasticity Test shows that residual values are not correlated with the error term.

4.1 Causality Analysis

Table 4.5 reveals the Granger causality result, of causation that exist between total energy consumption, labor and capital and gross domestic product (GDP).

Table 4.5: Granger Causality Test

Null Hypothesis:	Obs	F-Statistic	Prob.
TCON does not Granger Cause GDP		6.36803	0.0013*
GDP does not Granger Cause TCON		5.04878	0.0103*
LAB does not Granger Cause GDP		2.56320	0.0944*
* GDP does not Granger Cause LAB+		0.33704	0.0045*
CAP does not Granger Cause GDP		0.90055	0.4174
GDP does not Granger Cause CAP		2.26044	0.1224
LAB does not Granger Cause TCON		3.31071	0.0507*
TCON does not Granger Cause LAB		2.10244	0.1404

CAP does not Granger Cause TCON	1.45304	0.2504
TCON does not Granger Cause CAP	1.52409	0.2348
CAP does not Granger Cause LAB	0.47987	0.6237
LAB does not Granger Cause CAP	1.31826	0.2832

* denote rejection of hypothesis at 0.05 significant level **

Source: Author's computation

The result shown in table 4.5 depicts that a bidirectional relationship exists between total energy consumption and gross domestic product, similar to results from Onakoya *et al*, 2013.. Similarly labor and gross domestic product have a bidirectional causal relation. Furthermore, the result shows one-way causation from labour to petroleum consumption. The causality implies that there is a feedback impact between petroleum consumption and economic growth, also from labour and economic growth. This result aligns with proponents of feedback energy and growth causation.

5.0. Conclusion

This paper presented the relationship between economic growth and energy consumption separated into petroleum and electricity consumption using the ARDL approach. The bound test and long run estimate suggest a long run relationship between economic growth and petroleum as well as labour. Similarly, the short run estimation suggests that both petroleum consumption and labour have a significant positive relationship with economic growth, while electricity consumption is not significant. The country's reliance on petroleum resources, which is the major source of revenue, is a possible explanation of why economic growth is positively affected by petroleum resources. Indeed as living conditions improve with income, so does electricity consumption. Electricity, which is mostly consumed by the household, has no significant bearing on economic growth over the years, implying any productive effect their consumption may have on the economy is not visible through electricity use.

The causality result reveals that feedback causation runs from economic growth to total energy consumption and labour respectively and one-way causation from labour to economic growth. This result depicts the key role the household sector plays in shaping energy demands in Nigeria and economic growth.

Indeed, it has been hypothesized that Nigeria has enormous energy resources in the country that exceed its energy requirement, but these resources are utilized inefficiently. The country has relied on the petroleum sector over the years, whereas the high volatile nature of the petroleum market is indeed a treat to sustainable growth. Hence policy reforms targeted towards the expansion and diversification of the power-generation portfolio in the country would help provide efficient energy sources. In the absence of efficient energy generation identified in this paper, full deregulation the power sub-sector of the economy to private sector participation in the generation, transmission and distribution of electricity would improve energy consumption..

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