A VAR Analysis of the Relationship between Energy Consumption and Economic Growth in Nigeria

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ABSTRACT
The indispensible factor for sustainable economic development in every economy is energy. It is an engine room for rapid socio-economic growth and development. In Nigeria, the problem of insufficient electricity supply (power) is as the result of lack of diversification of energy sources. Electricity generation cannot cope with the ever increasing demand for the product. As a result of rapid population growth, access to modern energy remains relatively low and inequitable. However, there is a functional relationship between the quantity of electricity generation (megawatt) and sustainable development in the economy. This paper investigated the direction of this functional relationship between energy and sustainable economic development using the Granger causality test. Also a multiple regression analysis was adopted to explore the impact of energy consumption on economic growth. The result showed that energy consumption had a bidirectional relationship with GDP growth, and directly contributed significantly to economic development in Nigeria. To this end, therefore, there is need for policy makers to boost investment in the energy sector in order to increase its supply, and meeting the demand for energy with a view to meeting the expectations of the millennium development goals.
Keywords: sustainable development, energy consumption, energy potentials and economic growth

1. INTRODUCTION

The benefits of energy to every economy cannot be over-emphasised. It is the foundation to other aspects of development. This could be through increase in foreign earnings generated from the exportation of energy products, reduction of unemployment by energy industries, transfer of technology in the process of exploration, improvement in infrastructure in the process of energy resource exploitation and many other benefits to the economy. Energy plays the most vital role in the economic growth, progress, and development, as well as poverty eradication and economic security of any nation. Increase in economic growth significantly depends on the continuing availability of energy from sources that are affordable, accessible, and also environmentally friendly. The standard of living of a given country can be directly related to the per capita energy consumption as energy is an important factor in all the sectors of any country's economy. These include provision of basic needs such as cooked food, lighting, powering appliances, piped water or sewerage, essential health care (refrigerated vaccines, emergency, and intensive care), educational aids, communication (radio, television, the use of IT equipments), and transport to mention but few. Energy also fuels productive activities including agriculture, commerce, manufacturing, industry, and mining.

On the contrary, the inadequate supply and lack of access to available energy contributes to economic decline, ultimately poverty and other deprivations. According to Nnaji, et al. (2010) and quoted in Oyedepo (2012), Energy and poverty reduction are not only closely connected, they are also related with the socioeconomic development, involves productivity, income growth, literacy, and health status. It is suspected that the presence of high incidence of poverty in the Nigerian economy today is not unconnected with incessant energy crises. These have engulfed the nation for almost three decades, thereby paralyzing industrial and commercial activities during this period. This was confirmed by the Council for Renewable Energy of Nigeria which estimated that power outages brought about an annual loss of 126 billion naira (US$ 984.38 million), (CREN, 2009). This also has negative effects on the environment, in terms of the level of carbon emissions caused by invariable use of generators as an of alternative to central supply of energy needed by households and business enterprises, brings unemployment, and high cost of living leading to a deterioration of living conditions. As Toman and Jemelkova (2003) state, the mainstream economics literature on this issue is somewhat limited. Business and financial economists do pay significant attention to the impact of oil and other energy prices on economic activity in the short-run, but the mainstream theory of economic growth pays little or no attention to the role of energy or other natural resources in promoting economic growth.

There is no doubt that, the optimal development as well as efficient management and utilization of energy resource will put the economy on the part of sustainable (growth and) development. What needs to be understood is whether energy leads economic growth or vice versa and how energy contributes to economic growth. This paper had investigated empirically these issues vis-a-vis direction of causality and contributions of energy to sustainable economic development in Nigeria. The paper is grouped into six sections. Following this section is the literature review, this have both conceptual and empirical literature in energy and the economy. Nigeria's energy potential. This paper is organised in six sections. The subsequent sections are; literature review; theoretical framework; data and method of analysis; empirical strategy and policy recommendations as well as conclusion.

2. REVIEW OF LITERATURE

2.1 ENERGY AND THE ECONOMY

The energy sector plays a pivotal role in attempts to achieve sustainable development, balancing economic and social developments with environmental protection (encapsulated in the 'strap line' for the 2002 Johannesburg World Summit on Sustainable Development of 'people, planet, and prosperity'). Energy is central to practically all aspects of sustainable development. Energy is central to the economy because it drives all economic activities. This characterization of energy directs our attention to its sources in nature, to activities that convert and reconvert this energy, and finally to activities that use the energy to produce goods and services for household consumption. Traditionally, energy is treated as an intermediate input in the production process. This treatment of energy's role underscores its importance and contribution to development. All economic activities and processes require some form of energy. This effectively makes energy a critical primary factor of production. Given the state of technological advancement in the economy, capital and labour perform supporting roles in converting, directing, and amplifying energy to produce goods and services needed for growth (and poverty reduction).

Energy services are essential ingredients of all three pillars of sustainable development - economic, social, and environmental. Economies that have replaced human and animal labour with more convenient and efficient usage of energy and technology are also the ones that have grown fastest. No country in modern times has succeeded in substantially reducing poverty without adequately increasing the provision and use of energy to make material progress (Rosen 2009). Indeed, by not ensuring a minimum access to energy services for a broad segment of the population, economic development of developing countries such as Nigeria beyond the level of subsistence has proven to be a real challenge.

At the national level, energy propels economic development by serving as the launch pad for industrial growth and, via transport and communications, providing access to international markets and trade. Reliable, efficient, and competitively priced energy supplies also attract foreign investment - a very important factor in boosting economic growth in recent times. At the local level, energy facilitates economic development by improving productivity and enabling local income generation through improved agricultural development (irrigation, crop processing, storage, and transport to market) and through non-farm employment, including micro-enterprise development. As an indicator of local recognition of the importance of energy to businesses, Nigerian manufacturers, who were asked to rank the constraints on their firms' activities, identified power breakdowns, and voltage fluctuations as their top two problems (ECN, 2008;Oyedepo, 2012).

Physical theory shows that energy is necessary for economic production and therefore growth. There is no understanding of the role of energy in economic growth without proper understanding of the role of energy in production. Energy consumption in an economy being the biggest input for economic and social development needs to be sufficient in supply for it to achieve sustainable development. Economic growth is a precondition for a nation to move from underdeveloped or developing economy to a developed one. For a developing country like Nigeria, the greater the economic growth, the better its chances to become developed with adequate development of her energy potentials to meet the demand, the nation would experience high levels of economic development. According to Alam (2006), energy is the indispensable force driving all economic activities. This implies that, the greater the energy consumption, the more the economic activities in the nation and as a result a greater economy emerges. All economic processes must require energy; this therefore, makes energy always an essential factor of production (Stern, 1997a).Today, Nigeria is seen as one of the largest developing nations in Africa with highly endowed natural resources including potential energy resources. These resources serve as the pillar of wealth creation but have short fall in its generation. Meanwhile, when dealing with sustainable development, it requires the reconciliation of environmental, social equity and economic demands (known as the "three pillars" of sustainability).

There are numerous organizations in the world within the academic and commercial sectors conducting large scale advanced research in the field of sustainable energy having discovered that energy promotes economic development. This research spans several areas of focus across the sustainable energy spectrum including solar and wind geothermal, among others. Most of the research is targeted at improving efficiency and increasing overall energy yields. To this extent, the presence of reliable energy supply will not only uplift the rural populace from social backwardness, but will also enable them to tap their economic potentials that have remained untapped. The country's high propensity to import means roughly 80% of government expenditures is recycled into foreign exchange. Cheap consumer imports, resulting from a chronically overvalued Naira, coupled with excessively high domestic production costs due in part to erratic electricity and fuel supply, reduced utilization of industrial capacity to less than 30%.Government, professionals and academics alike are concerned about the impact of energy consumption on the economy.

1.2 NIGERIA'S ENERGY POTENTIALS

Many researchers (Onyebuchi (1989), Adekoya and Adewale (1992), Akinbami (2001), Fagbenle and Karayinnis (1994), Chineke and Igwiro (2008), Ngala et al (2010)) have looked into the availability of renewable energy resources in Nigeria with a view to establishing their viability in the country's economy. Onyebuchi estimated the technical potential of solar energy in Nigeria with 5% device conversion efficiency put at 15.0×10^{14} kJ of useful energy annually. This equates to about 258.62 million barrels of oil equivalent annually, which corresponds to the current national annual fossil fuel production in the country. This is source of wealth to Nigeria's economy and will amount to about 4.2×10^5 GW/h of electricity production annually; about 26 time the recent annual electricity of production of 16,000 GW/h in the country. This, if tap, would reduce cost of production or doing business in the country, increase level of investment, create employment and reduce poverty. To Chineke and Igwiro, Nigeria receives abundant solar energy that can be usefully harnessed with an annual average daily solar radiation of about 5.25 kW h/m^2/day. This was shown in their work as quoted in Oyedepo (2012). This solar energy potential varies between 3.5 kW h/m^2/day at the coastal areas and 7 kW h/m^2/day at the northern boundary. The average amount of sunshine hours all over the country is estimated to be about 6.5 h. This gives an average annual solar energy intensity of 1,934.5 kW h/m^2/year; implying that, over the course of a year, an average of 6,372,613 PJ/year (approximately 1,770 TW h/year) of solar energy falls on the entire land area of Nigeria. According to the study, this is about 120,000times the total annual average electrical energy generated by the Power Holding Company of Nigeria (PHCN). With a 10% conservative conversion efficiency, the available solar energy resource is about 23 times the Energy Commission of Nigeria's (ECN) projection of the total final energy demand for Nigeria in the year 2030, ECN (2005) . This source of energy can be harnessed as a reliable and sustainable source of power supply to enhance the sustainable developmental trend in the country.

In the area of wind energy, Adekoya and Adewale and other researchers have also explored the availability of wind energy sources in Nigeria. In 1992, Adekoya and Adewale analyzed the wind speed data of 30 stations in Nigeria and determine that annual mean wind speeds and power flux densities vary from 1.5 to 4.1 m/s and 5.7 to 22.5 W/m^2, respectively. Two years after, Fagbenle and Karayiannis carried out a 10-year wind data analysis from 1979 to 1988, to discover the wealth potentials of wind in Nigeria. Ngala,et al (2007) performed a statistical analysis of the wind energy potential in Maiduguri, Borno State, using the Weibull distribution and 10-year (1995 to 2004) wind data. A cost benefit analysis was also performed using the wind energy conversion systems for electric power generation and supply in the State. According to Oyedepo review on this work, each of these reports point to the fact that the nation is blessed with a vast opportunity for harvesting wind for electricity production, particularly at the core northern states, the mountainous parts of the central and eastern states, and also the offshore areas, where wind is abundantly available throughout the year. The contribution of wind energy to the development of our economy is quite enormous. It is left for the country to look at ways of harnessing resources towards establishing wind farms in various regions and zones that have been identified as possessing abilities for the harvesting of wind energy.

Akinbami (2001), reports that the estimated total hydroelectric power potential of the country is about 8,824 MW with an annual electricity generation potential in excess of 36,000 GW h. This consists of 8,000 MW of large hydropower technology, while the remaining 824 MW is still small-scale hydropower technology. Presently, about 26% and 5% of both large and small hydropower potentials, respectively, in the country have been exploited. Oyedepo (2012) points out that Akinbami, et al.'s assessment indicated that the identified feedstock substrate for an economically feasible biogas program in Nigeria includes water lettuce, water hyacinth, dung, cassava leaves, urban refuse, solid (including industrial) waste, agricultural residues, and sewage. The authors' views include the following: Nigeria produces about 227,500 tonnes of fresh animal wastes daily. This is another source of wealth for the nation's energy sector and hence, the Nigerian economy Since 1 kg of fresh animal wastes produces about 0.03 m^3 gas, then Nigeria could produce about 6.8 million m^3 of biogas every day. In addition to all these, 20 kg of municipal solid wastes per capital has been estimated to be generated in the country annually.

For the past thirty years, researchers have explored the relationship between energy consumption and economic growth for different nations and time using diverse methodologies so that a broad literature has been accumulated in this field. Alam (2006) accepted the fact that there is a departure from neoclassical economics doctrine which includes only capital, labour and technology as factors of production to one which now includes energy as a factor of production. He added that energy drives the work that converts raw materials into finished products in the manufacturing process. Simpson (1969), states that there is a bidirectional relationship between energy and economic growth. Yu and Choi (1985) in their research work carried out on the Philippines economy, find that there is a positive relationship between energy consumption and economic growth. Further they define the relationship as a unidirectional one where economic growth served as the dependent variable and energy consumption was the independent variable. Kraft and Kraft (1978) found a unidirectional relationship from expansion in GDP to energy consumption in USA. They point out that an increased in GNP will cause a corresponding increase in the consumption of energy as a factor of production. Erol and Yu (1987) examined the relationship between energy consumption and GDP for six developed countries (Canada, Italy, Japan England, France and Germany) for the period 1952 to 1982 and they find a bidirectional causality relationship for Japan, unidirectional from GDP to energy consumption for Germany and Italy, unidirectional from energy consumption to GDP for Canada. They discover non causality for France and England. Sten (1993) examines the relationship between the USA's energy consumption and her GDP using a multivariate co-integration model and concludes that there is no relationship. His work in 2000 still confirms his previous result. In a similar research carried out on economy of Singapore and Indonesia Asafu-Adjaye (2000) arrives at the same unidirectional causality between Energy consumption and Economic growth. This is certainly so especially in the electricity sub- sector as the positive relationship between electricity consumption and economic growth has been justified by some researchers as being consistent.

Many economists agree that there is a strong correlation between electricity use and economic development. Morimoto and Hope (2001) have discovered, using Pearson correlation coefficient, that economic growth and energy consumption in Sri Lanka are highly correlated. A co-integration analysis conducted by Ageel and Mohammad, (2001) on energy and its relationship with economic growth in Pakistan reveals that increase in electricity consumption leads to increased in economic growth. Soytas, Sari and Ozdemir (2001),in a similar study for Turkey from 1960 to 1995 have a similar result with that of USA (of unidirectional causality but from energy consumption to GDP for that period). Soytas and Sari (2003), in a study of Italy and Korea and Ghosh (2002) for India from 1950 to 1997, discover a unidirectional causality from economic activities to electricity. Fatai, Oxley and Scrimgeour (2002) conducted the same research for New Zealand. Jumbe (2002), in his own work done for Malawi examine the relationship between energy (electricity) and GDP and discover a bidirectional relationship. According to Breshin (2004), electricity is vital for driving growth in the energy, manufacturing and social sector. Zon and Chau (2005) in their research to examine the relationship between crude oil and China's GDP find that there is no co-integration between oil consumption and GDP from 1953 to 2002. However, due to liberalization of China's economy in 1984 they decided to divide this period into the period before the liberalization (1953 to 1984) and that after liberalization (1985 to 2002). For the period after liberalization, the result shows that there is co-integration relationship between oil consumption and GDP.

Altinary and Karagol (2005) find a strong long-run causality running from energy consumption to the real GDP in Turkey. Rufael (2006) examines the relationship between electricity consumption and real GDP in 17 African countries from 1971 to 2001 using limit test approach and finds that there is co-integration relationship for the 12 countries. However, the direction of causality was from GDP to electricity consumption in six countries from electricity consumption to GDP in three of them while bidirectional causality was found in three countries. In the same vein, Lee and Chang (2007) investigate a relationship between energy consumption and real GDP in 22 developed and 18 developing countries. In their research, they found that there is unidirectional causality from real GDP to energy consumption in the developing countries and there is bidirectional causality between energy consumption and real GDP in the developed ones.

According to Sanchis, (2007), "electricity as an industry is responsible for a great deal of output". And went on to say that electricity had effects not only on factors of production but also on the impact it had on capital accumulation. According to him, an increase in the electricity will production boost the manufacturing capacity and increases the level of industrial production. Increased industrial production eventually increases output and reduces unemployment. This implies that electricity production should receive an economic policy's high-priority attention which should be urgently responded to.

3. Theoretical Framework

According to received economics, Classical economists did not recognize energy as a factor of production in the production process, neither did the neoclassical economists. Today, economists have developed models that incorporate the role of resources including energy in the growth process. Time series analyses have shown that Energy and GDP co-integrate and energy use Granger causes GDP when additional variables such as energy prices or other production inputs are included. The primary driving force of economic growth is the growth of productivity, which is the ratio of economic output to inputs (capital, labour, energy, materials and services (KLEMS)).This has led to several criticisms of the neoclassical economic theory and other theories of growth, on a number of grounds, especially on the basis of the implications of thermodynamics for economic production and the long-term prospects of the economy. Therefore, there have been paradigm shifts towards incorporating energy into the modern growth model to reflect the role of energy in the economy.

Consequently,(Stern, 1999) notes that energy is a factor of production that is non-reproducible, though of course energy Vectors - fuels - are reproducible. (see also, Hall, et al., 2001 and 2003). In the extreme, energy use rather than output of goods is used as an indicator of the state of economic development (e.g. Kardashev, 1964).

There have been different theories of economic growth before the growth theory proposed by Romar, (1994), Solow–Swan model, also known as exogenous growth model. The Solow-Swan model attempts to explain long-run economic growth by looking at productivity, capital accumulation, population growth, and technological progress. At its core is the neoclassical aggregate production function of Cobb–Douglas type, which enables the model "to make contact with microeconomics"(Acemoglu, 2009). One of the basic assumptions of the Solow model is the diminishing returns to labour and capital and constant returns to scale as well as competitive market equilibrium and constant savings rate, which is adopted from the Domar model. However, what is crucial about the Solow model is the fact that it explains the long run per capita growth by the rate of technological progress, which comes from outside the model.

By the mid-1980s, a group of growth theorists had become increasingly dissatisfied with common accounts of exogenous factors determining long-run growth. They favoured a model that replaced the exogenous growth variable (unexplained technical progress) with a model in which the key determinants of growth were explicit in the model. Consequently, the Endogenous (new) growth theory emerged due to some flaws in the exogenous growth theory and holds that economic growth is primarily the result of endogenous and not external forces (Romer, 1994). Endogenous growth theory holds that investment in human capital, innovation, and knowledge are significant contributors to economic growth. The theory also focuses on positive externalities and spill over effects of a knowledge-based economy which will lead to economic development. In the new growth model, the savings rate and rate of technological progress are unexplained. Endogenous growth theory tries to overcome this shortcoming by building macroeconomic models out of their microeconomic foundations. Households are assumed to maximize utility subject to budget constraints while firms maximize profits. Crucial importance is usually attached to the production of new technologies and human capital. The engine of growth can be as simple as a constant return to scale production function (the AK model) or more complicated set ups with spill over effects (spill over are positive benefits of a firm that are attributed to costs from other firms), increasing numbers of goods, increasing qualities, etc.

Often endogenous growth theory assumes constant marginal product of capital at the aggregate level, or at least that the limit of the marginal product of capital does not tend towards zero. This does not imply that larger firms will be more productive than small ones, because at the firm level the marginal product of capital is still diminishing. Therefore, while it is possible to construct endogenous growth models with perfect competition, in many endogenous growth models the assumption of perfect competition is relaxed, and some degree of monopoly power is thought to exist.

According to the AK production model
The simplest form of production function with diminishing return is:

$Y = AK$

Where;

A, is a positive constant that reflects the level of technology in the economy.

K is capital

Using the Romar model, a typical firm's production function can be depicted as;

$Y = f(AK, L)$
where:

A – public ideas and innovations (technological changes)
K – Capital stock of the firm
L –Labour stock of the firm

'A' includes the development of new ideas which are mainly done by the government since they are non-rival. When these new ideas that create enabling environment for smooth running of business are added to the model as factors of production the returns to scale tend to be increasing. This makes new technology the vital machinery for the achievement of long run growth and it is itself derived from investment made in research technology.
In this model, Romar regards investment in research technology as an endogenous factor.
From the forgoing, an aggregate production function can be derived from the endogenous theory as follow:
Y=F (A, K, L)
Where
Y = aggregate real output.
K = stock of capital.
L = stock of labour.
A = Technology (or changes in technological inputs)
Borrowing from Gbadebo and Okonkwo (2009),we note that A (technological advancement) is based on the investment on research technology. This technology is seen as an endogenous factor which could be related to energy. All economic processes require energy. Therefore, energy is always an essential factor of production and it is capital intensive. Here we follow Gbadebo and Okonkwo (2009) model and modify it to capture natural gas in order to assess the contribution of energy to economic development in Nigeria.

3.1 Model Specification

In order to investigate the nature of the contributions of energy to economic development, we have used Gbadebo and Okonkwo (2009), augmented with natural gas consumption to investigate the effect of energy on the economy. The model used is stated as follows:
Y = f (K. L, E) .... (3.1)
where:
Y = RGDP
K = Gfcf = Gross fixed capital formation
L = Labf = Labour force
E = Total Energy Consumption
However, energy, E in the model is disaggregated into 4 energy types: petroleum (PT), electricity (ELCTR), natural gas (GAS), and coal. Therefore, splitting E into these, the model is restated as follows:
RGDP = f (Gfcf, Laf, PT, ELCTR, Coal, gas) .... (3.2)

For purpose of estimation we rewrite equation (3.2) above in the linear form, as:
$RGDPt = \alpha_0 + \alpha_1 Gfcf_t + \alpha_2 Laf_t + \alpha_3 ELCTR_t + PT_t + GAS_t + COAL_t + U_{1t}$ ..... (3.3)

where:
α_1 to α_3 represent the slope coefficients
α_0 is the intercept
$U_{1t}$is the stochastic term or the error term at time t

a Priori expectations are as follows:
$\alpha_1>0, \alpha_2>0, \alpha_3>0, \alpha_4>0, \alpha_5>0, \alpha_6>0,$

In the non-linear form we also estimated

$$lnRGDP_t = \beta_0 + \beta_1 lnGFCF_t + \beta_2 lnLABF_t + \beta_3 lnPT_t + \beta_4 lnELCTR_t + \beta_5 lnGAS_t + \beta_6 lnCOAL_t + U_{2t}$$

where;

β_1 to β_6 are elasticities and β_0 is the intercept

U_{2t} is the error term.

This is the form reported here, since the log values will be better than the natural values.

3.2 DATA AND METHOD OF ANALYSIS

Annual time series data covering 1980 - 2011 have been used. The basic data for this analysis are GDP, gross fixed capital formation (Gfcf) as proxy for capital, labour force, total energy, disaggregated energy (crude oil, natural gas, electricity and coal) and also GDP per capita as well as energy per capita. These data were collected from two main sources: International Energy Statistics Year Book - a publication of the IEA (International Energy Association) and Statistical Bulletin - a publication of the Central Bank of Nigeria. All variables except are in logarithmic form.

There is a general tendency for time series data to contain a unit root. Consequently, an attempt has been made to render the data stationary prior to specification and estimation. Moreover, as the residuals of non-stationary time series are correlated with their own lagged values, a standard assumption of ordinary least squares (OLS) theory, that disturbances are not correlated with each other, is violated. Hence, OLS estimates of such series are biased and inconsistent, and standard errors computed with such random walk variables are generally underestimated. In that case, OLS is no longer efficient among linear estimators (Ndiyo, 2003). This study employs a vector autoregressive (VAR) technique that is commonly used for forecasting systems of interrelated time series and for analyzing the dynamic impact of random disturbances on a system of variables.

The adoption of VAR is informed by the fact that VAR methodology of potentially spurious a prior constraints that are employed in the specification of structural models. Also, since few restrictions are placed on the way in which the system of variables interacts, this method is well suited for examining the channels through, which a variable operates. The VAR approach sidesteps the need for structural modelling by modelling the endogenous variable as a function of its lagged value. Since only the lagged value of the endogenous variable appears on the right hand side of the equation, there is no issue of simultaneity. In effect, the strength of the VAR model lies in its ability to incorporate the residual from the past observation into the regression model for the current observation. The approach also has the advantages of being easy to understand, generally applicable, and easily extended to nonlinear specifications and models that contain endogenous right-hand-side variables. In addition, the nonlinear least squares estimates of this method are asymptotically equivalent to maximum likelihood estimates and are asymptotically efficient. The coefficient may be interpreted in the usual manner, but the results involving the residuals, differ however, from those computed under OLS settings (Ndiyo and Ebong 2004).

4. Empirical strategy

We approach the issue of energy contributions to sustainable development from Nigeria's experience in the following four stages: the correlation analysis, causality test; using Granger-causality test, the stationary test, and vector autoregressive (VAR) regressions.

4.1 Correlation analysis

The correlations matrix below provides the opportunity to assess the degree of multicollinearity between the variables of the model before the regression analysis. The first column of figures indicates the correlation between the dependent variable and the explanatory variables. The other columns indicate the correlations of the independent variables to themselves and to each other.

TABLE 1: CORRELATION MATRIX OF GROWTH AND ENERGY VARIABLES

	LOGGDP	LOGGFCF	LOGLABF	LOGELCTR	LOGGAS	LOGPT	LOGCOAL
LOGGDP	1.000000						
LOGGFCF	0.982166	1.000000					
LOGLABF	0.984895	0.984012	1.000000				
LOGELCT	0.906824	0.902123	0.926417	1.000000			
LOGGAS	0.752856	0.749185	0.812473	0.733648	1.000000		
LOGPT	0.635498	0.633131	0.676247	0.544767	0.848635	1.000000	
LOGCOAL	-0.847661	-0.856041	-0.867830	-0.722437	-0.729922	-0.653971	1.000000

Source: Computed by the Authors

First the correlation between GDP (dependent variable) and the independent variables show remarkable coefficients that range between 0.75 and 0.98. It is observed that all the variables have strong relationships with one another apart from electricity with crude oil (petroleum) that has a coefficient of 0.54. This implies that multicollinearity exists and is a serious problem in the model, if estimated with OLS method as this will violet assumption 8 of ordinary least squares.

4.2 STATIONARITY TEST

Table 2 below depicts the result of stationarity test conducted for the model;

TABLE 2: Stationarity test

VARIABLE	ADF	REMARK	PP	REMARK
GDP	3.652506	I(0)	5.29666	I(I)
GFCF	11.10371	I(0)	4.91304	I(0)
LABF	6.554431	I(0)	6.88393	I(0)
PT	-2.69225**	I(0)	-2.69566**	I(0)
GAS	-6.86809	I(I)	-6.86809	I(I)
ELCTR	-7.5639	I(I)	-7.45457	I(I)
COAL	-3.25018*	I(0)	3.25239*	I(0)
CRITICAL VALUE: 1% -3.6701 5% -2.9639 10% -2.6210 *stationary at 5% ** stationary at 10%			CRITICAL VALUE: 1% -3.6616 5% -2.9604 10% -2.6191	

Source: Computed by the Authors

The test shows that, using Augmented Dickey-Fuller (ADF) test, only electricity and gas are integrated of order one while the remaining variables are integrated at level. In comparison, in the Philips-Perron (PP), GDP, in addition to the two variables in the ADF test that are not stationary at level, is not stationary at level while others are stationary at level. We thus conclude that they have unit roots Dickey and Fuller, 1981; Hendry, 1986; Engel and Granger, 1987, Philips and Perron, 1988; Johnansen, 1988.

4.3 CAUSALITY TEST

In this study, we used Granger causality test to check the direction of influence of the two key variables; economic growth and energy (though we tested for all the variables; both total energy and disaggregated variables; as indicated in the result in table 3, we will only concentrate on GDP and total energy).The Granger causality assumes that the information relevant to the prediction of the respective variables, GDP and energy (En), is contained solely in the time series data on these variables. The test involves estimating the following pair of regressions:

$$GDP_t = \sum_{i=1}^{n} \alpha_i En_{t-1} + \sum_{j=1}^{n} \beta_j GDP_{t-j} + u_{1t} \ldots\ldots\ldots (4.1)$$

$$Ent = \sum_{i=1}^{n} \gamma_i En_{t-1} + \sum_{j=1}^{n} \delta_j GDP_{t-j} + u_{2t} \ldots\ldots\ldots (4.2)$$

where it is assumed that u_{1t} and u_{2t} are uncorrelated. Equation (4.1) postulates that current GDP is related to past values of itself as well as that of energy (En), and equation (4.2) postulates a similar behaviour for energy. The result of this test, shown in table 3, indicates that there is a bidirectional relationship between GDP and energy consumption in Nigeria. This implies that energy affects GDP and GDP in turn affects energy in the Nigeria's economy. This result then prompted the use of VAR in this study as the use of OLS technique will give a biased and inconsistent estimation because of the violation of a crucial assumption of the OLS (assumption 6): μ is independent of the explanatory variable(s). Symbolically;

$$Cov(X\mu) = E\{[Xi - E(Xi)]\ [\mu i - E(\mu i)]\} = 0 \ldots\ldots\ldots (4.3)$$

TABLE 3: RESULTS OF GRANGER CAUSALITY TEST

NULL HYPOTHESIS	F-STATISTIC	PROBABILITY	DECISION
GDP does not granger cause electricity	2.36000	0.11512	Reject
Electricity does not Granger cause GDP	3.81336	0.03586	Reject
GDP does not Granger cause PT	0.69014	0.51081	Accept
PT does not Granger cause GDP	1.83036	0.18112	Accept
GDP does not Granger cause gas	3.57310	0.04316	Reject
Gas does not Granger cause GDP	69.9827	0.000057	Reject
GDP does not Granger cause coal	0.62493	0.54345	Accept
coal does not Granger cause GDP	0.61168	0.55036	Accept
GDP does not Granger cause energy	5.01454	0.01475	Reject
energy does not Granger cause GDP	26.4002	0.00000069	Reject

No. Of Obs. 30
Source: Computed by the Authors

4.4 VECTOR AUTOREGRESSIVE (VAR) REGRESSION

TABLE 4: RESULT OF ESTIMATED MODEL

INDEPENDENT VARIABLES	DEPENDENT VARIABLES	
	LOGGDP	LOGENGY
C	-0.274160 (-0.24171)	0.269496 (0.79816
LOGGDP(-1)	0.9517 (5.894)	0.048205 (1.00286)
LOGGDP(-2)	0.084709 (0.40211)	-0.067410 (-1.07492)
LOGENGY(-1)	3.473438 (5.37408)	0.65352 (3.3966)
LOGENGY(-2)	2.989843 (3.69791)	0.34477 (1.43245)
LOGGFCF	0.552709 (2.70831)	-0.119955 (-1.71133)
LOGLABF	2.838896 (1.21428)	0.433601 (0.53998)
Akaike AIC	0.672652	-1.750778
Schwarz SC	0.906184	-1.517245
Mean dependent	14.39402	-0.260017
S.D. dependent	2.483857	0.206138
Determinant Residual Covariance		0.000842

t-statistic in ( )
Source: Computed by the Authors

The explanatory power of the VAR is high across the two specifications shown in table 4 the R^2 and even the adjusted R^2 in the results are satisfactory, indicating that the arguments highly explain variations in the national output. Most of the estimated parameters have the expected signs and statistically significant at 5% level of significance. The Akaike information criteria and Schwarz criteria values show that the model is good for the system.

1. Energy is observed to be directly related to (having a positive effect) to growth, and is statistically significant, confirming a positive contribution of energy to the economic growth of the nation and hence development. It also promotes the growth of current energy in the economy
2. The second lag value also has a positive influence on the output. This further strengthen the fact that energy is vital to the growth and development of the Nigerian economy as it helps in the development of the current energy consumption in the economy as seen in the second equation.
3. Investment in the economy measured by gross fixed capital formation (GFCF) promotes economic growth as shown in the result. But do not promote the development in the energy sector though not statistically significant in the second equation.
4. Labour force promotes economic growth. And also energy consumption in our country.
5. Existing capacity (previous level of wealth; GDP) promotes the current level of GDP in the economy and energy consumption as well in the first lag year.
6. Only in the second year that existing capacity does not promotes economic growth and also indicate its negative impact to the energy sector, though it is not statistically significant.

5. POLICY IMPLICATIONS AND RECOMMENDATIONS

The negative impact of capital to energy in the model shows that much capital is not channel into the energy sector to harness the huge potential that is available in this sector in other to accelerate economic growth and development. The positive impact of energy in the model gives a clear indication that energy contributes substantially to the development of the Nigerian economy. But it is sad to observe in the model that the growth in the national income does not promote the energy sector which also confirms the inverse relationship of the gross fixed capital formation (proxy for capital). To this extent, the following recommendation has been made;

1 Increased investment in the energy sector. Policies should be made to boost investment in the energy sector since, according to the result; energy is an engine room for economic development in Nigeria. This will increased the level of total energy that will be available in the economy for consumption and in the long-run the multiplier effect will be increased in employment, total productivity as well as poverty reduction in the economy.

2 Diversification of energy source: energy should be produce from abundant renewable sources in the country, other than petroleum and hydropower, to increase the quantity of power available for the manufacturing sector and business environment. For example, harvesting; wind for electricity production, particularly at the core northern states, the mountainous parts of the central and eastern states, and also the offshore areas, where wind is abundantly available throughout the year; potential of solar energy in Nigeria with a 5% device conversion efficiency put at 15.0×10^{14} kJ of useful energy annually and amount to about 4.2×10^{5} GW/h of electricity production annually, which is about 26 times the recent annual electricity production in GW/h in the country. This solar potential if taped will equates to about 258.62 million barrels of oil equivalent annually. This will drastically reduce the costs of production and doing business in Nigeria, encourage new investment and increase in economic activities; in the long-run, promote development.

3 Since increase in energy encourages increase in economic growth as seen in the result, proper research should be made to foster innovation in this sector to achieve energy efficiency. Also, natural gas infrastructures are required in the country to reduce natural gas flare. Availability of such facilities will increase gas production and consumption, and possibly no doubt, economic growth.

6. SUMMARY AND CONCLUSION

In this paper, we explored the contributions of energy to sustainable development in Nigeria through; review of empirical studies; theoretical issues; and centred on empirical findings using econometric method of correlation analysis, causality test and vector autoregressive (VAR) analysis. From our findings we discovered that energy in Nigeria has a bidirectional effect with gross domestic product (GDP).This increased in energy consumption will lead to increased in the economic growth. Although this is contrary to Olaniyan (2010) which concludes in his work that energy consumption is not a cause of economic growth. Our findings show that energy consumption is a propeller to rapid economic growth. Therefore, since Nigeria is blessed with abundant energy resources, if these energy are adequately harnessed the economy will tread to the path of sustainable development.

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