THE RELATIONSHIP BETWEEN ENERGY CONSUMPTION AND ECONOMIC GROWTH IN NIGERIA: A CAUSALITY ANALYSIS

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Abstract:

This study investigates the causal relation between energy consumption and economic growth in Nigeria. Time series data was generated covering 1970 to 2009 periods. The study used both aggregated and disaggregated data of energy consumption; including coal, petroleum, gas, and electricity. In analyzing the data, we employ the Augmented Dickey Fuller unit root tests and Johansen cointegration tests allowing for Granger causality test. The results infers that neither total energy consumption nor economic growth affect each other. On the other hand, finding reveals that petroleum, coal and electricity consumption leads to economic growth without feedback. Moreover, bidirectional causality between economic growth and gas consumption was found. The implication of the finding is that an energy conservation policy will retard economic growth for Nigeria. This imply that energy act as an engine of growth for the country and so the neutrality hypothesis of energy consumption and economic growth is not supported, by this study, in Nigeria.

Keyword: Economic growth, Nigeria, energy consumption, cointegration, causality

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1. Introduction:

Indeed Nigeria is endowed with abundant resources both human and natural resources (crude oil inclusive), but it has been classified among the poor countries in terms of its per capita income (Umoh and Ibanga, 1997). This raises crucial question, what is the relationship between energy consumption and economic growth in the country? Although the relationship is well established in some developing country like Taiwan, Pakistan, China among others. However, the issue of Nigeria's case is subjected to the academic debates. The contribution of other sectors (especially the agricultural sector) of the economy to the Gross Domestic Product (GDP) has significantly eroded. In the last three decades or so, petroleum (oil) has claimed the top position in Nigeria's export list, constituting a very fundamental change in the structure of the country's international trade.

Production and consumption activities are not possible without energy, as a required input, making it indispensable source of economic growth. At the same time economic growth may induce the use of more energy (Lee and Chang, 2005). This situation was ignored until petroleum crisis in 1970s displayed the importance of energy in productive process (Erbaykal, 2008). Examining energy by separating it into its components, it is seen that electricity is the highest quality energy component and its share in energy consumption increases, rapidly, whereas natural gas, petroleum, coal and bio-fuels follow electricity respectively.

The rest of the paper is organised as follows. The next section is the literature review, section three discusses the methodology, empirical finding is presented in section four and the final section concludes the paper.

2. Literature Review:

The relationship between energy consumption and economic growth is now well established in the literature, yet the direction of causation of this relationship remains controversial. That is, whether economic growth leads to energy consumption or that energy consumption is the engine of economic growth. The direction of causality has significant policy implications. Empirically it has been tried to find the direction of causality between energy consumption and economic activities for the developing as well as for the developed countries employing the Granger or Sims techniques. However, results are mixed (Aqeel and Butt, 2001). This type of study receives the attention of scholars following the pioneering work of Kraft and

Kraft (1978). In their study on the relationship between the United State of America's (USA) energy consumption and Gross National Product (GNP) for the period 1947-1974; a unidirectional causality relation running from GNP to energy consumption was found. Reexamining the relationship between two variables in question for USA by Akarca and Long (1980) could not found the relationship between GNP and energy consumption for 1947-1972 period. Yu and Chai (1985) however, found causality from energy to GDP in the Philippines, but this causality is reversed in the case of the Republic of Korea.

Panel study by Erol and Yu (1987) on the relationship between energy consumption and GDP for England, France, Italy, Germany, Canada and Japan with the data of 1952–1982 period and the causality relationships they found were bidirectional for Japan, unidirectional from energy consumption to GDP for Canada and unidirectional from GDP to energy consumption for Germany and Italy. While causality for France and England could not be ascertained. Furthermore, time series analysis of the causal relationships between energy and employment in USA by Erol and Yu (1988), Using Granger method. The study found no relationship between the variables. However applying different method of data analysis (Sim's techniques), they discovered that energy consumption negatively effected employment. A bi-directional causality between growth of energy consumption and GNP growth was observed in Taiwan Province of China by Hwong, et al., (1991) while Cheng and Lai (1997) found causality from economic growth to energy consumption and from energy consumption to employment without feedback in Taiwan Province of China.

Electricity consumption has an important place in measuring the level of socio-economic development of particular country. Ferguson et al., (2000) examined the relationship between electricity consumption and economic development for 100 countries and found a strong relationship between the two variables concerned. Stern (2000) examined the causality between energy consumption and GDP of the USA for the period 1948 to 1994 with a multivariate model and his results shows no evidence of causal relationship between the variables.

Disaggregating the energy into sub-components (electricity, gas, coal, petroleum etc) mixed results was also documented. For instance Aqeel and Butt (2001) investigate the causal relationship between energy consumption and economic growth and energy consumption and employment in Pakistan. By applying techniques of co-integration and Hsiao's version of Granger causality, the results infer that economic growth causes total energy consumption.

Economic growth also leads to growth in petroleum consumption, while on the other hand, neither economic growth nor gas consumption affect each other. However, in the power sector it has been found that electricity consumption leads to economic growth without feedback. The implications of the study are that energy conservation policy regarding petroleum consumption would not lead to any side-effects on economic growth in Pakistan. However, an energy growth policy in the case of gas and electricity consumption should be adopted in such a way that it stimulates growth in the economy and thus expands employment opportunities. Ghosh (2002) examined economic growth and electricity consumption of India for the period 1950 to 1997 and found a unidirectional causality relationship from economic growth to electricity consumption.

Moreover, Jumbe (2004) examined the relationship between electricity consumption and GDP of 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. An interested study by Zou and Chau (2005) found no cointegration between oil consumption and GDP, in China for the period of 1953-2002. Studying the relationship between energy consumption and GDP of Taiwan by Lee and Chang (2005) for the period 1954–2003, uses aggregate as well as various disaggregate data of energy consumption, including coal, oil, gas, and electricity, to employ the unit root tests and the cointegration tests allowing for structural breaks. Their main findings indicates though gas consumption seems to have structural breaks in the 1960s, after considering the structural breaks, the series is a stationary variable when Taiwan adopted its expansionary export trade policy. They also found bi-directions causality between GDP and various kinds of energy consumption.

A panel study by Rufael (2006) examined the relationship between electricity consumption and GDP for 17 African countries for the period 1971 to 2001 with limit test approach and found cointegration relationship in 9 countries and Granger causality relationship for 12 countries. While the direction of causality is from GDP to electricity consumption in 6 of these countries and from electricity consumption to GDP in 3 of them; bidirectional causality was found in 3 countries. Erbaykal (2008) investigated energy consumption and economic growth relation disaggregates, using oil and electricity consumption for energy consumption for 1970-2003 periods in Turkey. Bounds test approach for cointegration relationship was the techniques of the data analysis employed in his study. Co-integration test results shows that in short run both oil consumption and electricity consumption has positive and statistically significant effect on economic growth, however, in long run oil consumption has positively effect on economic growth while electricity consumption has negative effect. But in long run the electricity and oil consumption coefficients are statistically insignificant and therefore the study concludes that both electricity and oil has short run effect on economic growth.

The impact of oil prices on exports earnings and economic growth was investigated in the case of Pakistan and India by Saher (2011) using the data from 1971 to 2009. The Johansen cointegration and Fully Modified Ordinary Least Square (FMOLS) methods were employed as the techniques of data analysis. The empirical findings indicates that the long run relationship exist among the variables in both countries cases. The oil prices (also squared term) is impeded the exports earning, and human capital, physical capital and economic growth are enhanced the exports earning, and in the second economic growth model, the human capital, physical capita and oil prices are economic growth enhancing factors in the case of Pakistan. On the other hand in the case of India human capital, physical capital and oil prices positively related to exports earnings whereas economic growth negatively related to exports earnings.

In light with the inconsistencies and conflicting findings, the results could therefore be categorized as follows: If there does exist a causality running from energy consumption to GDP, then this denotes an energy-dependent economy such that energy is an impetus for GDP (Kraft and Kraft, 1978; Shiu and Lam, 2004). On the other hand, if there is a reverse chain of causality from GDP to energy, then this denotes a less energy-dependent economy such that energy conservation policies may be implemented with little adverse or no effect on GDP (Oh and Lee, 2004). Finally, the finding of no causality in either direction, the so-called neutrality hypothesis (Yu and Choi, 1985; Altinay and Karagol, 2004), means that energy conservation policies do not affect GDP.

3. Methodology:

This study examined the causal relation between aggregate energy consumption and economic growth on the one hand and disaggregates energy consumption and economic growth on the other had for Nigeria. Basically, to test for the causal relationship between two variables, the standard Granger (1969) test has been employed in the relevant literature. This test states that, if past values of a variable Y significantly contribute to forecast the value of another variable X_{t+1} then Y is said to Granger cause X and vice versa. The test is based on the following regressions:

$$Y_t = \beta_0 + \sum_{K=1}^{M} \beta_K Y_{t-k} + \sum_{l=1}^{N} \Phi_l X_{t-1} + U_t ....1$$

$$X_t = \lambda_0 + \sum_{K=1}^{M} \lambda_K X_{t-K} + \sum_{l=1}^{N} \delta_l Y_{t-1} + V_t ....2$$

Where Y_t and X_t are the variables to be tested, Y_{t-1} and X_{t-1} are lagged value of the variables, U_t and V_t are mutually uncorrelated white noise errors, t denotes to time period, k and ι are number of lags. The null hypothesis is $\Phi_1 = \delta_1 = 0$ for all observations while the alternative hypothesis is $\Phi_1 \neq 0$ and $\delta_1 \neq 0$ for at least for some observations. If the coefficient Φ_i's are statistically significant but δ_i's are not, then X causes Y and vice versa. But if both Φ_i and δ_i are both significant, then causality runs both side.

According to Granger (1986) causality test is valid if the variables are not cointegrated. As result, we checked the property of the variables using Augmented Dickey Fuller (ADF) (1979) unit root test for stationarity. This test is based on the following regression model:

$$\Delta Y_t = \beta_0 + \beta_1 T + aY_{t-1} + \sum_{j=1}^{k} d_j \Delta Y_{t-j} + \varepsilon_t ....3$$

Where Y_t , T and Δ respectively confers a time series, a linear time trend and first difference operator, β_0 is a constant, k is respecting the optimum number of lags on the dependent variable, and ϵ_t is random error term. The null hypothesis for testing nonstationarity is H_0: $\alpha = 0$ meaning economic series are non-stationary. If the hypothesis of non-stationary is established for the underlying variables, it is desirable and important that the time series data are examined for cointegration.

Two or more variables are said to be cointegrated if they share common trends i.e. they have long run equilibrium relationships (Aqeel and Butt, 2001). There are various methods of detecting these long relations between variables. Engle and Granger's (1987) approach for cointegration is simple and popular for its certain agreeable attributes. However, it did not permit the testing of hypotheses on the cointegrating relationships themselves, but the Johansen setup does permit the testing of hypotheses about the equilibrium relationships between the variables (Brooks, 2008). Other advantage of the Johansen's procedure is that several co-integration relationships can be estimated and it fully captures the underlying time series properties of the data (Saher, 2011).

Johansen (1988) cointegration technique is based on the vector autoregressive (VAR) models; it involved two test statistics for the number of cointegrating vectors: the trace (λ_{trace}) and the maximum value statistics (λ_{max}). In the trace test, the null hypothesis is that the number of distinct cointegrating vectors is less than or equal to r, where r = 0 to 2. In each case the null hypothesis is tested against the general alternative. The maximum eigenvalue test is similar, except that the alternative hypothesis is explicit. The null hypothesis is that the number of cointegrating vectors is r against the alternative of r+1 cointegrating vectors.

The econometric model employed to establish the relationship between GDP and energy aggregate consumption is given below:

$$GDP_t = \beta_0 + \beta_1 enercomp_t + \varepsilon_t ....4$$

Where GDP is real GDP (using 1990 constant price), Enercomp is energy consumption, β's are the parameters to be estimated and ε is white noise error term.

$$GDP_t = \lambda_0 + \lambda_1 petrol_t + \lambda_2 Gas_t + \lambda_3 Coal_t + \lambda_t Elect + \upsilon_t ....5$$

In the disaggregate model above, petrol denotes to petroleum consumption, Gas is Gas consumption, Coal is Coal consumption, Elect is Electricity consumption, λ's are parameter of the model and υ is uncorrelated error term. The data for relevant variables was sourced from Central Bank of Nigeria Statistical Bulletin of various issues covering the period for 1970 to 2009.

4. Empirical Results:

The degree of integration of each variable involved is determined using the Augmented Dickey Fuller unit root test based on equation 3. The result is presented in Table 1 below.

Table1: Result of unit root tests

Variable	Augmented Dickey-Fuller (ADF) Test	
	Levels	First Difference
GDP	-2.631	-4.260***
Eneconp	-1.342	-4.845***
Petrol	-2.044	-4.251***

Gas	-2.691	-4.372***
Elect	-.1.231	-3.912**
Coal	-2.573	4.651***

*** ** indicate significance at 1% and 5% level of significance

Source: data analysis, 2011

It could be discerned from the above Table that variables are not stationary at their level form and so unit root test are rejected. However, the test rejects the null hypothesis of non stationary for the all variables when used in the first difference. This shows that all series are stationary in the first difference and integrated of order one. Therefore we used the difference values of the variable to estimate the cointegration regression and the result of the cointegration is presented in the Table 2 below.

Table 2: Johansen Co-integration Results

Model	λ_{max} statistics		λ_{trace} statistics	
	r=0	r=1	r=0	r=1
GDP, Encomp	9.599	0.047	9.646	0.047
GDP, Petrol	8.635	1.437	10.072	1.437
GDP, Gas	4.897	0.004	4.901	0.004
GDP, Elect	10.803	0.085	10.889	0.085
GDP, Coal	9.153	0.048	9.200	0.048
5% critical value	14.07	3.76	15.41	3.76

Source: data analysis, 2011

The results of the Johansen (1988) maximum likelihood tests for λ_{max} (maximum statistics) and the λ_{trace} (Trace test statistics) was presented in above Table. Various lag lengths are tried and the lag structures are chosen by the Akaike Information Criterion (AIC) and Schwartz Information Criteria (SIC). They suggest 1 lag for the model. According to Cheung and Lai (1993), the Trace test shows more robustness to both skewness and excess kurtosis in the residual than the maximum test. Both the Trace statistic and maximum statistics suggests no cointegrating vector among all cases. The absolute values of the calculated test statistics for all the residuals are less than its critical value at the 5 per cent level. Therefore, neither of the series are cointegrated. Therefore the standard Granger test seems to be appropriate.

Table 3: Vector Autoregression

Variables	Coefficient	Probability
GDP	0.977 (12.86)***	0.000
Enerconsump	229.133 (2.75)***	0.006
Petrol	13.518 (1.98)**	0.057
Elect	1.201 (4.07)***	0.000
Gas	43.300 (2.01)**	0.044
Coal	25.43 (5.89)***	0.000

*** ** indicates significant at 1% and 5% levels respectively

Source: data analysis, 2011

The result of Vector Autoregression is presented in the Table above. It shows that the coefficient of GDP, energy consumption, electricity consumption and coal are positive and significant at 1 percent level of significance. The coefficients of Gas and petroleum are also positive and significant at 5 percent level. The results confirm the existence of causality at least in one direction.

Table 4: Granger causality test

Variables	**Prob>chi^2**
GDP-Enercomp	0.163
Enercomp-GDP	0.698
GDP-Petrol	0.537
Petrol-GDP	0.033
GDP-Coal	0.838
Coal-GDP	0.051
GDP-Gas	0.044
Gas-GDP	0.018
GDP-Elec	0.508
Elec-GDP	0.011

Source: data analysis, 2011

The result of Granger causality test is presented in Table 4 above. The result shows no evidence of causality between GDP and energy consumption. The finding is consistence with that of Akarca and Long (1980), Erol and Yu (1980) and that of Zou and Chau (2005) which documented absence of causality between aggregate energy consumption and economic growth for USA, France, England and China respectively. The Table also indicates that petroleum consumption causes increase in GDP and not vice versa. This finding do not refuted the finding of Aqeel and Butt (2001), Erbaykal (2008) and that of Saher (2011). A unidirectional causality is established running from coal to GDP. Moreover, bidirectional causality between economic growth and gas consumption was detected. Having only bidirectional relation between gas consumption and economic growth is not surprising in Nigeria because electricity sector is in severe failure resulting to manufacturing companies, corporate enterprises, households, governments and its agencies to resort alternatives source of power (generators) which consumes more of gas. However, the results reported for electricity consumption and GDP states that electricity consumption leads to economic growth without feedback. This finding supported the findings of Gosh (2002), Lee and Chang (2005) and that of Rufael (2006) which revealed unidirectional causality between electricity consumption and economic growth.

5. Conclusion:

This study investigates the relationship between energy consumption and economic growth in Nigeria. Specifically we established the causal relation between the variables in question. Energy consumption was disaggregated into it components consisting petroleum, gas, coal and electricity. For the analysis, we used Granger causality test which found appropriate by using Johansen cointegration technique and finding out that there is no cointegration between the variables concerned. Prior to this, the property of the variables where tested using ADF unit root test and the first difference value appeared stationary for all the variables.

According to estimated results, neither economic growth nor total energy consumption affect each other. The finding confirms the existence of energy crises in the country. Therefore, it becomes necessary for government to find possible ways of redressing the low energy consumption prevailing in Nigeria so that the sector in question could play its role of enhancing economic performance. Further investigation indicates that petroleum, coal and electricity consumptions lead to economic growth. The implication of this finding is that energy growth policy should be adopted in such a way that these sectors continue to stimulate economic growth which in turn would enhance economic activities and reduces unemployment. The study also found bidirectional causality between economic growth and gas consumption. The causality test under the different energy component emphasize unanimously that an energy conservation policy will retard economic growth for Nigeria. This imply that energy act as an engine of growth for the country and so the neutrality hypothesis of energy consumption and economic growth is not supported in Nigeria

References:

- Akarca, A. and Long, T. (1980), Relationship between Energy and GNP: a Reexamination, Journal of Energy and Development, 5 (1): 326–331.
- Altinay, G. and Karagol, E., (2004), Structural Break, Unit root, and the Causality between Energy Consumption and GDP in Turkey. Journal of Energy Economics, 26: 985–994.
- Aqeel, A. and Butt, M. (2001), the Relationship between Energy Consumption and Economic Growth in Pakistan. Asia Pacific Development Journal, 8(2) : 101-110.
- Brooks, C. (2008): Introductory Econometrics for Finance. New York. Cambridge University Press.
- Cheng, S. and Lai, T. (1997), An investigation of Cointegration and Causality between Energy Consumption and Economic Activity in Taiwan Province of China, Journal of Energy Economics, 19: 435-444.
- Dickey, D. and Fuller, W. (1979), Distribution of the Estimator for Autoregressive Time Series with a Unit Root. Journal of the American Statistical Association 74: 427– 431.
- Erbaykal, E. (2008), Disaggregate Energy Consumption and Economic Growth: Evidence from Turkey. International Research Journal of Finance and Economics, 20:172-179. htpp://www.eurojournal.com/financec.htm. Accessed on 23rd July 2011.
- Engel, R. and Granger, W. (1987) Co-integration and Error Correction Representation, Estimation and Testing, Econometrica, 55(2) : 251-276.
- Erol, U. and Yu, H. (1987). The Relationship between Energy and Income for Industrialized Countries, Journal of Energy and Employment, 22:113-122.

- ____________ (1988), Time Series Analysis of the Causal Relationships between U.S. Energy and Employment", Resources and Energy, 16: 75-89.
- Ferguson R., Wilkinson W., and Hill R.(2000), Electricity Use and Economic Development, Energy Policy, 28: 923–934.
- Ghosh, S. (2002), Electricity Consumption and Economic Growth in India. Energy Policy, 30: 125-129.
- Granger, W. (1969), Investigating Causal Relations by Econometrics Models and Cross Spectral Methods", Econometrica, 37: 424-438.
- ____________,(1986), Developments in the Study of Cointegrated Economic Variables. Oxford Bulletin of Economics and Statistics, 48: 213-228.
- Hwang, M, Dennis, B. and Gun-Burel, K. (1991), The Causal Relationship between Energy and GNP: The Case of Taiwan Province of China, Journal of Energy and Development, 16: 219-26.
- Johansen, S. (1988), Statistical Analysis of Cointegration Vectors, Journal of Economic Dynamics and Control, 12 (2/3):231-254.
- Jumbe, C. (2004), Cointegration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi. Energy Economics, 26: 61-68.
- Kraft, J. and Kraft, A. (1978), the Relationship between Energy and GNP, Journal of Energy and Development, 3:401-403.
- Lee, C. and Chang, C. (2005), Structural Breaks, Energy Consumption, and Economic Growth Revisited: Evidence from Taiwan. Energy Economics, 27(2005): 857-872. http.//www.sciencedirect.com. Accessed 7th May 2011.
- Oh, W. and Lee, K. (2004). Energy Consumption and Economic Growth in Korea: Testing the Causality Relation. Energy Economics 26: 51– 59.
- Rufael, W. (2006), Electricity Consumption and Economic Growth: A Time Series Experience for 17 African Countries. Energy Policy, 34:1106–1114.
- Saher, N. (2011), Impact of Oil Prices on Economic Growth and Exports Earning: In the Case of Pakistan and India. Romanian Journal of Economics, XIV(40): 117-151.
- Shiu, A. and Lam, P. (2004), Electricity consumption and economic growth in China. Energy Policy, 32: 47– 54.

- Stern, I. (2000) ,Multivariate Cointegration Analysis of the Role of Energy in the US Macro-economy. Energy Economics, 22: 267–283.
- Umoh, G. S. and Ibanga, I. O.(1997). An Alternative Micro-credit Delivery Model for Poverty Alleviation in Nigeria . Conference Proceeding. NES. Pp. 521-631.
- Yu, H. and Choi, Y. (1985), The Causal Relationship between Energy and GNP: an International Comparison. Journal of Energy Development, 10: 249–272.
- Zou, G and Chau, W. (2005), Short and Long Run Effects Between Oil Consumption and Economic Growth in China, Energy Policy, Article in Press.