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CONSUMPTION, CO_2 EMISSIONS AND ECONOMIC GROWTH: AN EMPIRICAL EVIDENCE FROM NIGERIA.

Aribatise Adekunle[1] & Elufisan Omowunmi Olaronke[2]

[1] Department of Economics, Wesley University, Ondo, Ondo State, Nigeria.
[2]Department of Economics, Accounting and Finance, Bells University, Sango Ota, Ogun State
Email: kundun95@gmail.com

Abstract: The study examined the causal relationship and dynamic interaction among Energy Consumption (ENCOM), Carbon Dioxide Emission (CO_2) and Gross Domestic Product (GDP) in Nigeria. These were with the view to examining the relative effectiveness of CO_2 Emission and Energy Consumption on the Nigerian economy. Annual data over the period of 1980 to 2015, sourced from the World Bank Development Indicators, and the Central Bank of Nigeria (CBN) Statistical Bulletin, were used for the study. Time series econometrics (Granger Causality and Vector Error Correction Model) was applied to test the causal relationship, and the interaction among the variables respectively. The results established a unidirectional causality among CO_2 and ENCOM and GDP; meaning that as the economy experiences growth, there exist a corresponding increase in Energy Consumption as people tends to consume more energy, thus the rate of pollution also increases. The variance decomposition showed that a shock on CO_2 Emissions and ENCOM respectively have significant and lasting impact on the Nigerian gross domestic product i.e. a possible increase in CO_2 emissions which results in decline in environmental quality may generate negative externalities for the economy and that Energy which is a direct input in the production process is seen as a prerequisite for economic growth in Nigeria. The paper recommends that the Government should enact policies that will enable firms to utilize advance technology which emits less carbon dioxide and enhances domestic production. Therefore, concerned authorities can achieve a dramatic drop in carbon intensity by encouraging and introducing the use of wind, solar, geothermal and other clean renewable resources of energy

Keywords: VECM, Economic Growth, CO_2 Emission, Energy Consumption, Variance, Decomposition

Aribatise Adekunle[1] & Elufisan Omowunmi Olaronke[2]

INTRODUCTION

World economies are heavily reliant on energy and Nigeria is not an exception. As Alam (2006) puts it, "energy is the indispensable force driving all economic activities." In other words, the greater the energy consumption, the more the economic activity in the nation and as a result, a greater economy emerges. Today, Nigeria is seen as one of the greatest developing nations in Africa with highly endowed natural resources including potential energy resources.However, increasing access to energy in Nigeria has proved to be not only a continuous challenge but also a pressing issue with the international community. One of the key principles in a developing economy like Nigeria is to achieve 'sustainable development'. The most well-known definition of sustainable development that is accepted by the United nations (UN) is 'development that meets the needs of the present without compromising the ability of future generations to meet their own needs'. In achieving sustainable development,there are many aspects that should be taken into consideration therefore, the Division for Sustainable development under the UN department of Economic and Social Affairs has listed down the fields within the scope of sustainable development, 'climate change' and 'energy'are among the main focuses (UN, 2007). Nigeria as the giant of Africa has been on the focus of the world for its surprising GDP growth as well as high energy demand growth in recent years. For instance, statistics have shown that the Nigerian economy has consistently grown by an average of over 6 percent in the last few years. The economy grew at 5.3 percent in 2011; 4.2 percent in 2012 and 7.4 percent in 2014; exceeding 5.5 percent in 2013 and about 2.1 % in the first quarter of 2016. But in spite of this impressive consistent growth, electricity supply in Nigeria has remained erratic. This automatically led to the shift to alternative sources of power that has largely required burning of fossil fuels and subsequent increase in emission level. Therefore exploring the link between energy consumption, economic growth and carbon dioxide emissions has become a major challenge since energy is been considered as the best tool to obtain sustainable development.

In recent times, a few studies have investigated the relationship between energy consumption, CO_2 emissions and economic growth. Shafik and Banhyopadhayay (1992), Shafik (1994) and Loganathan and Subramanan (2010) have hypothesized that the relationship between economic growth and environmental quality,whether positive or negative, is not fixed along a country's development path and indeed may change sign from negative to positive as a country reaches a level of income at which people demand and afford more efficient infrastructure. Also Tiwali (2011) found that CO2 emission has positive impact on energy and capital but negative on population and GDP, Nikolaos et al (2015) also revealed that the effects of the various types of energy consumption on growth and emissions are heterogenous. Though, these empirical investigations have been found to be inconclusive which calls for additional study to elucidate this association.Hence, the need for this study is imperative. Also, Soytas et al. (2007) and Soytas and Sari (2009) found unidirectional Granger causality running from energy consumption to pollution emissions in the long run, while Halicioglu (2009), Kaplan et al (2011), Zen and Chau (2006) found bidirectional Granger causality in the long run and short run between economic growth and pollution emissions. Zhang and Cheng (2009) found unidirectional Granger causality running from economic growth to energy consumption and energy consumption to pollution emissions in the long run, while Ang (2007) found unidirectional Granger causality running from economic growth to energy consumption and pollution emissions in the long run. Yet, a few have equally reported the absence of causality between the variables (Ghaderi et al, 2006; Zou and Chau, 2006).Nikolaos et al(2015) found a bi-directional causal relationship between economic growth and energy. Given the contentious and inconclusive nature of these views, therefore, there is need to determine the causal relationship among the variable so as to ascertain the direction and strength of the potential feedback among them. Hence, this study, the paper is arranged in 5 sections. Section one is the introduction while section two reviews the literatures on the study. The methodology and the empirical results are presented in sections three and four respectively. Section five concludes and makes policy recommendations based on the study

LITERATURES

Lean and Smyth (2010), using the Granger Causality test, EKC in ASEAN countries between the periods of 1980-2006 found out that the long run estimates indicate that there is a statistically significant positive association between carbon dioxide emission and energy consumption and a non-linear relationship between carbon dioxide emissions and real GDP, consistent with the EKV. The long run estimates do not however indicate the direction of causality between the variables. The results from the Granger Causality tests suggest that in the long run, there is unidirectional Granger causality running fron energy consumption and carbon dioxide emissions to economic growth. The results also point to unidirectional granger causality running from carbon dioxide emissions to energy consumption in the short run. Apergis and Payne (2009) examined the Cointegration, VECM techniques, the Granger Causality test, EKC in Central America through 1971-2004. They found out that in the long run equilibrium, energy consumption has a positive relationship and statistically significant impact on carbon dioxide emissions while real GDP exhibits the invented U-shaped pattern associated with the EKC hypothesis. The short run dynamics indicate unidirectional causality from energy consumption and real GDP, respectively to emissions along with bidirectional causality between energy consumption and real GDP. In the long run, there appears to be bidirectional causality between energy consumption and carbon dioxide emissions. Nikolaos et al (2015) In their study examined the dynamic interrelationship in the output-energy-environment nexus by applying panel vector autoregression (PVAR) and impulse response function analyses to data on energy consumption (and its subcomponents), carbon dioxide emissions and real GDP in 106 countries classified by different income groups over the period 1971{2011. Our results reveal that the effects of the various types of energy consumption on economic growth and emissions are heterogeneous on the various groups of countries. Moreover, causality between total economic growth and energy consumption is bidirectional, thus making a case for the feed- back hypothesis. Kais and Sami (2015)in their paper attempts to investigate the impact of economic growth and CO_2 emissions on energy consumption for a global panel of 58 countries using dynamic panel data model estimated by means of the Generalized Method of Moments (GMM) for the period 1990–2012. We also estimate this relationship for three regional panels; namely, from Europe and North Asia, Latin America and Caribbean, and Sub-Saharan, North African and Middle Eastern. The empirical evidence indicates significant positive impact of CO_2emissions on energy consumption for four global panels. Economic growth has a positive impact on energy consumption and statistically significant only for the four panel. Also, Jafari et al (2012) probed the relationship between energy consumption, economic growth and carbon dioxide emissions but incorporating capital and urbanization as potential determinants of energy consumption and energy pollutants. They noted that there is no long run relationship between the variables and urbanization granger causes energy consumption. The empirical findings of mentioned studies are inconclusive and are not helpful to policy makers in articulating comprehensive economic, energy,financial, trade and environmental policy to sustain economic growth and hence environmental quality in case of Indonesia due to not considering financial development and trade openess while investigating the relationship between economic growth, energy consumption and carbon dioxide emissions.

Glasure (2002) used a five-variable vector ECM to study the (Granger) causality between economic growth and energy consumption in South Korea. Government expenditure is used as a substitute for government activity, money supply is used as a substitute for monetary policy and prices of oil are also included as an important factor in explainng the causality. The period 1961 to1990 was covered in the study. He provided evidence to support a bidirectional causation, and the oil price is found to have the most significant impact on GDP and energy use.
Chebbi and Boujelbene (2009) using time series data from Tunisia for the period 1971-2004 and employing Multivariate Cointegration, the combined results of Causality analysis and impulse response functions do not assume that energy and GDP are neutral with respect to each other in Tunisia but rather indicates a bidirectional causality between GDP and energy consumption in the long run implying that Tunisia is an energy dependent economy. But using different data set, Ansgar et al (2012) applied the techniques of panel unit root and Cointegration tests to investigate energy consumption and economic growth of 25 OECD countries for the period 1981-2007, they found a bidirectional causal relationship between energy consumption and economic growth, contrary to this study is Ozturk and Acaravci (2010) who discovered that there is no causal relationship between carbon dioxide emissions per capital, energy use per capita, and real GDP per capita in Turkey between the periods of 1968-2005. He further used the ARDL bounds testing approach of cointegration. Narayan and Narayan (2010) assessed the EKC hypothesis panel analysis in developing countries. The results showed that if the long run GDP elasticity is smaller than the short run GDP elasticity, then it is evident that a country has reduced carbon dioxide emissions as its GDP has increased. Another study by Tsani(2010) conducted in greece using time series data for the period 1960-2006 through the application of ARDL model and Toda and Yamamoto multivariate model, their findings indicates the evidence of bidirectional Granger causality between energy consumption and CO2 emissions in the long run but neutral relationship between energy consumption and economic growth which invariably implying that India

could pursue conservation policies without harming economic growth. In summary, it is evident that there exist in the literatures conflicting results as regards the relationship amongst CO_2 emission, energy consumption and economic growth. Therefore, there is need for a more detailed analysis of the relationship amongst the variables in Nigeria. Hence, this study

METHODOLOGY

Unit Root Test

Most of time series have unit root as demonstrated by many studies including Nelson and Plosser (1982), Stock and Watson (1988) and Campbell and Peron (1991). Therefore, their means of variance of such time series are not independent of time. Conventional regression technique based on non-stationary time series produce spurious regression and statistic may simply indicate only correlated trends, Granger and Newbold (1974).Therefore, the unit root test is carried out to determine the order of integration of the data series.

Co-integration

Though prior to undertaking cointegration test, it is desirable that all the variables are integrated of the same order i.e I(1), the notion of cointegration, which was given a formal treatment in Engel and Granger (1987), makes regression involving non-stationary time series meaningful. In VEC Models, the test for cointegration is vital because if there is no cointegrating relationship among variables under consideration then there is no point estimating VECM. A simple approach to test for the existence of cointegration is the Engle-Granger (1987) two-step approach. Though this procedure is easily implemented, but it has several limitations. One crucial limitation of the method is that it has no systematic procedure to identify the existence of multiple cointegrating vectors. An alternative approach which addresses the drawbacks of the two steps Engel-Granger approach was proposed by Johansen (1988), who developed the maximum likelihood estimation procedure that allows one to test for the number of cointegrating relationship. The Johansen (1988) maximum likelihood estimators overcome problems associated with the use of two step estimators. Most importantly, it can detect the presence of multiple cointegrating vectors. Moreover, the test allows testing restricted versions of the cointegrating vector(s) and the speed of adjustment parameters (Enders, 1995). Johansen and Juselius (1990) proposed two tests statistics to determine the number of cointegrating vectors (or the rank of Π), namely the trace (λ-trace) and the maximum eigen-value (λ-max) statistics. The trace statistic (λ-trace) is computed as:

$$\lambda_{trace} = -T \sum_{j=r+1}^{n} \ln(1 - \lambda_j) \qquad 3.1$$

The trace tests the null hypothesis that "at most" r cointegration vector, with "more than" r vectors being the alternative hypothesis. The maximum eigenvalue test is given as:

$$\lambda_{max} = -T\, ln(1 - \lambda_{r+1}) \qquad 3.2$$

The trace test (λ_{trace}) is a joint test where the null hypothesis is that the number of cointegrating vectors is less than or equal to r, against an unspecified alternative that there are more than r. On the other hand, the maximum Eigen-value test (λ_{max}) test the null hypothesis that the number of cointegrating is r against alternative of r+1. Johansen and Juselius (1990) provide critical values for both λ_{trace} and λ_{max}. If the test statistics is greater than the critical values, the null hypothesis that there exist r cointegrating vectors against the alternative hypothesis that are more than r (for λ_{trace}) or are r+1 (for λ_{max}) is rejected (Enders, 1995).

Vector Error Correction Model (VECM)

A natural progression from a VAR representation is the VEC model especially when the variables of interest are not stationary at their levels and are cointegrated. At this occasion, a vector error correction model (VECM) leads to a better understanding of the nature of any non-stationarity among the different variables in the series as well as their long-run equilibriums. One of the inherent benefits of VECM is that it combines the long-run relationship with a short-run adjustment process as it clearly distinguishes between short-run and long-run impacts and responses, thereby providing a suitable tool for policy analysis. As such, the vector error correction representation of standard VAR is given as follows:

$$\Delta y_t = \theta + \sum_{i=1}^{n} \beta_i\, y_{t-1} + \lambda ECM_{t-1} + \varepsilon_t \qquad 3.3$$

Where Δ is the differencing operator, such that $\Delta y_t = y_t - y_{t-1}$

Where y_t is an (nx1) column vector of the endogenous variables, θ is an (nx1) vector of constant terms, β represent coefficient matrices. y_t is the 3x1 vector of the variables included in the model (CO_2, ENCOM, GDP), θ is the 3x1 vector of constant terms and β is the 3x3 matrices which include the interactive coefficients of the variables involved in equation 3.3, and lastly λ is the 3x1 vector of coefficients for each of the error correction terms and ε_t is the vector of disturbance term. The vector error correction model pertaining to the three (3) variables incorporated into the model for the study is expressed below:

$$\Delta GDP_t = \alpha + \sum_{i-1}^{k} \beta_i \, \Delta GDP_{t-1} + \sum_{i-1}^{k} \theta_i \, \Delta CO2_{t-1} + \sum_{i-1}^{k} \pi_i \, \Delta ENCOM_{t-1} + \lambda_1 ECM_{t-1} + \varepsilon_{1t} \qquad 3.4$$

$$\Delta CO2_t = \alpha + \sum_{i-1}^{k} \beta_i \, \Delta GDP_{t-1} + \sum_{i-1}^{k} \theta_i \, \Delta CO2_{t-1} + \sum_{i-1}^{k} \pi_i \, \Delta ENCOM_{t-1} + \lambda_2 ECM_{t-1} + \varepsilon_{2t} \qquad 3.5$$

$$\Delta ENCOM_t = \alpha + \sum_{i-1}^{k} \beta_i \, \Delta GDP_{t-1} + \sum_{i-1}^{k} \theta_i \, \Delta CO2_{t-1} + \sum_{i-1}^{k} \pi_i \, \Delta ENCOM_{t-1} + \lambda_3 ECM_{t-1} + \varepsilon_{3t} \qquad 3.6$$

Equation 3.4 to 3.6 is therefore estimated to obtain the relationships that exist among carbon dioxide emission, energy consumption and economic growth.

Causality Test

In line with the third objective of this study, which is to identify the direction of causality among energy consumption, CO_2 emission and economic growth in Nigeria; The Multivariate Granger Causality test was employed which is based on the Wald test Chi-square statistic at 5% and the probability statistics.

Sources and Types of Data

The data collected for this study were obtained from secondary sources which include World Bank Development Indicators and the CBN statistical bulletin, 2016. The type of data collected was in form of annual, secondary time series data for the periods of 35 years (1980-2015). The data were used to analyze the impacts carbon dioxide emissions and energy consumption has on economic growth.

EMPIRICAL RESULTS

Unit Root Test Summary Statistics (Augmented Dickey Fuller)

To establish the degree of stationary of variables in this study, the Augmented Dickey Fuller (ADF) unit root test was performed. This is very important in the light of development in economic modeling which has revealed that most economic time series data are non-stationary in levels and could adequately be represented by first difference (Granger and Newbold, 1974). To avoid spurious regression problem, there is need to test for the stationary of the data.

Table 4.1: Augmented Dickey Fuller (ADF) Test

Variable	Augmented Dickey Fuller (ADF)Test			
	Level	First Difference	5% critical value	Remarks
GDP	0.388726	-3.318842	-2.986225	I(1)
CO_2	-2.054610	-9.054791	-2.986225	I(1)
ENCOM	-2.444382	-5.118753	-2.986225	I(1)

Source: Author's computation (2017)

Table 4.1, shows that the series could adequately be regarded as a random walk when they are in their levels but reverts to their mean level after first differencing. The null hypothesis that a variable under investigation has a unit root, against the alternative that it does not, could not be rejected for all the series in their levels at 5% significance level. Having taken the first difference of all the series, The test reveals that all the series are integrated of order one i.e. I(1). A co-integration test was further embarked upon to verify if long run relationship exists among the variables.

Co-integration Result

Having shown that the variables are integrated of order one, I(1), it is necessary to determine whether there is at least one linear combination of these variables .In other words, is there a stable and non-spurious (co-integrated) relationship among the regressors in each of the relevant specifications? This was done by using the Johansen and Juselius (1990) co-integration method because it is capable of determining the number of co-integrating vectors for any given number of non-stationary series(of the same order).

Table 4.2: Unrestricted co-integration test

Eigenvalue	Max-Eigen statistics	Trace statistics	5% critical level	Hypothesized No. of CE(s)
0.715501	30.16864	44.20628	29.79707	None*
0.409698	12.65090	14.03764	15.49471	At most 1*
0.056144	1.386748	1.386748	3.841466	At most 2

Source: Author's computation (2017)

Table 4.2 above, shows the result of the Johansen cointegration test for the series; CO_2, ENCOM and GDP. The test indicates that the presence of one cointegrating equation among the series. Hence, there is a significant long run equilibrium relationship among the variables.

Variance Decomposition

Shock in Carbon Dioxide Emission (CO_2)

The result shows the extent to which a standard deviation shock in CO_2 in Nigeria affects Energy Consumption (ENCOM) and the country's gross domestic product (GDP) over time. A one-time shock on CO_2 affects GDP and ENCOM from the second lag period. However, GDP absorbs about 10% of the shock in the second lag. The effect increases over time from 64% in the 3rd lag to about 78% in the future. This implies that the effect of shock on CO_2 on the Nigeria GDP does not die out but last far into the future. Increasing CO_2in Nigeria has the potential to correspondingly reduce the growth of economy over a long time. i.e. an increase in air and noise pollution, and a persistent decline in environmental quality may generate negative externalities for the economy through reducing health human capital and, hence, productivity decreases, thus the decrease in GDP.

Shock in Energy Consumption (ENCOM)

A standard deviation shock on Energy consumption (ENCOM) affects both CO_2 and GDP from the first lag period. However, the magnitude of the impact varies among the two variables. Empirical result indicates that GDP absorbs up to 9% of the shock in the first and up to 78% till the 10th lag period. Similarly, a standard deviation shock in ENCOM contributes increasingly to about 25% of shock on CO_2 in the 3 lag period. Hence, a variation in ENCOM has a lasting and significant impact on GDP over time, and the impact hardly dies out. This shows that Energy consumption is a prerequisite for economic growth given that energy is a direct input in the production process and as more and more energy is consumed, the economy tends to experience growth. The empirical finding is consistent with Mozumber and Marathe (2007) and Soytas and Sari (2003) which says that Energy consumption has a positive significant relationship with GDP in the country.

Multivariate Granger causality (Wald Test)

The Multivariate Granger Causality test is based on the Wald test Chi-sqaure statistic at 5% and the probability statistics. The optimum lag length of four (4) was used for the analysis. The Granger causality test shows that there are unidirectional causal relationships among the variables over the period under study. It is seen that ENCOM granger causes Co_2. We therefore reject the null hypothesis and accept the alternative hypothesis, this suggest that as more energy is consumed in Nigeria, the rate of Co_2 increases. Also, GDP granger causes ENCOM and CO_2; this also means that as the economy experiences growth, there will be a corresponding increase in Energy Consumption as people tends to consume, thus the rate of pollution also increases.

Table 4.3: Multivariate Granger Causality test

Null hypothesis (H_o)	X^2 Statistics	Probability	Remark
D(GDP) does not Granger cause D(CO_2)	6.0310	0.0301	Reject H_o
D(ENCOM) does not Granger cause D(CO_2)	2.0989	0.0112	Reject H_o
D(CO_2) does not Granger cause D(GDP)	3.8763	0.7986	Accept H_o
D(ENCOM) does not Granger cause D(GDP)	7.8307	0.9565	Accept H_o
D(CO_2) does not Granger cause D(ENCOM)	0.9499	0.8134	Accept H_o
D(GDP) does not Granger cause D(ENCOM)	0.0731	0.0449	Reject H_o

Source: Authors' Computation, 2017

Note: X^2 = chi-square

CONCLUSION

The study examined the causal relationship and dynamic interaction among Energy Consumption (ENCOM), Carbon Dioxide Emission (CO_2) and Gross Domestic Product (GDP) in Nigeria over the period of 1980 to 2015. These were with the view to examining the relative effectiveness of CO_2 Emission and Energy Consumption on the Nigerian economy. Multivariate Granger causality test was applied to test the causal relationship among the variables while the Variance Decomposition on a Vector Error Correction model was employed to examine the interactions between CO_2 and GDP, CO_2 and ENCOM, and ENCOM and GDP. The results established a unidirectional causality among CO_2 and ENCOM and GDP; meaning that as the economy experiences growth, there will be a corresponding increase in Energy Consumption as people tends to consume, thus the rate of pollution also increases. The variance decomposition showed that a shock on CO_2Emissions and ENCOM respectively have significant and lasting impact on the Nigerian gross domestic product. Therefore, a possible increase in CO_2 emissions which may results in decline in environmental quality may generate negative externalities for the economy through reducing health human capital and, hence, productivity decreases, thus the decrease in GDP. Also the lasting and significant impact Energy Consumption (ENCOM) has on GDP is not unconnected to the fact that energy consumption is a prerequisite for economic growth given that energy is a direct input in the production process and as more and more energy is consumed, the economy tends to experience growth. Therefore, both CO_2 emissions and Energy Consumption are instrumental variables that could catalyze the economy towards sustainable growth if manipulated appropriately through viable growth-driven policies. The Nigerian government should enact policies that enable the firm to utilize advance technology which emits less carbon dioxide and enhances domestic production. Therefore, concerned authorities can achieve dramatic dropsin carbon intensity by encouraging and introducing the use of wind, solar, geothermal and other clean renewable resources of energy.

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APPENDIX

Variance Decomposition of CO_2:

Period	S.E.	CO_2	GDP	ENCOM
1	118150.1	100.0000	0.000000	0.000000
2	150779.4	82.21208	10.34873	7.439185
3	279475.0	33.66463	64.16580	2.169571
4	1251990.	20.15020	79.67283	0.176969
5	6935627.	22.11464	77.87898	0.006382
6	38278762	21.69568	78.29966	0.004664
7	2.12E+08	21.77326	78.22166	0.005084
8	1.17E+09	21.78278	78.21179	0.005432
9	6.50E+09	21.78093	78.21354	0.005523
10	3.60E+10	21.78117	78.21329	0.005544

Variance Decomposition of GDP:

Period	S.E.	CO_2	GDP	ENCOM
1	45051.03	29.20000	70.80000	0.000000
2	258345.3	24.14886	75.79887	0.052271
3	1420806.	22.34888	77.62958	0.021534
4	7811425.	21.86922	78.11947	0.011303
5	43161883	21.77569	78.21764	0.006670
6	2.39E+08	21.77909	78.21511	0.005795
7	1.32E+09	21.78056	78.21385	0.005594
8	7.32E+09	21.78100	78.21344	0.005559
9	4.05E+10	21.78107	78.21338	0.005551
10	2.24E+11	21.78108	78.21337	0.005549

Variance Decomposition of ENCOM:

Period	S.E.	CO_2	GDP	ENCOM
1	19.56384	0.254036	9.018400	90.72756
2	27.57928	6.737522	6.690225	86.57225
3	78.30417	25.16996	59.39301	15.43704
4	424.1261	22.60445	76.77237	0.623174
5	2372.772	21.94992	78.03017	0.019911
6	13173.62	21.81671	78.17897	0.004322
7	72971.57	21.78611	78.20869	0.005198
8	404054.4	21.78213	78.21238	0.005484
9	2237142.	21.78126	78.21320	0.005538
10	12386323	21.78111	78.21334	0.005547

Reference to this paper should be made as follows: Aribatise Adekunle & Elufisan Omowunmi Olaronke (2017), Energy Consumption, Co_2 Emissions and Economic Growth: An Empirical Evidence from Nigeria. *J. of Sciences and Multidisciplinary Research,* Vol. 9, No. 4, Pp. 1-16