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Testing the Relationship between Energy Consumption and Economic Growth: Evidence from Nigeria and South Africa.

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Abstract

Energy demand, supply and pricing impact on socio-economic development, living standards and the overall quality of life of people. The role of energy in the industrial sector activities underscores its link with economic development. For more than three decades, economists and policymakers have been preoccupied with the classic debate on energy consumption and economic growth nexus. This Paper examines the causal relationship between energy consumption disaggregated into coal, hydro and oil, and economic growth in Nigeria and South Africa. Several studies have adopted the standard Granger causality method which places some minimum restriction on the stationarity property of data. Thus, the Hsiao's Granger causality version was applied to correct these restrictions for the comparative analysis. The estimated results reveal that economic growth causes total energy consumption in South Africa while energy consumption causes economic expansion in Nigeria. The economic implication of this finding is that sub-optimal utilization of energy resources through energy conservative policy may not lead to significant positive effect on economic growth in Nigeria. However, energy enhancement policy could engender economic growth in South Africa.

Key words: Energy Consumption, Economic Growth and Energy policy.

I Introduction

One of the key policy objectives of any nation is to promote a sustainable economic growth process that could improve the living standard of the people. Although there are various sources of economic growth (Busari, 1996 and Iyoha, 2002), the importance of energy in the economic development process particularly for developing countries is well documented in the literature (ADB, 1996; Iwayemi, 1983, 1993, 1998; Orubu, 2004; Omotor, 2007 and Sambo, 2008). Energy demand, supply and pricing impact positively on the socio-economic development, living standards, and the overall quality of life of people (Iwayemi, 1998). More fundamentally, the roles of energy in the industrial sector activities underscore its link with economic development. Energy-based resources and inputs constitute major components of industrial raw materials and value added in both developed and developing countries. Several studies have equally figured prominently on the negative impacts of energy uses (Omojolaibi, 2009 and Okafor 2011).

The importance of energy has gained prominence in the growth and economic development effort of nations, since the first oil price shock in 1973/74 and 1979/80 and reverberated vigorously with the continuously increasing demand for energy through out the 2000 decade. According to Iwayemi (1998), rapid industrialization and economic progress before the 1973 era can be attributed to the relatively cheap and abundant energy in the developed world, however, the rate at which energy consumption has increased closely followed the rate at which economies have expanded globally. Consequently, the literature has been preoccupied with the determination of the casual relationship and direction between energy consumption and economic growth. Some studies have revealed that energy consumption predates economic growth while other suggested that economic expansion leads to increase in energy consumption. There are some studies with evidence of bidirectional causality between energy consumption and economic growth as well as those with no causal relationship. The lack of consensus in this direction suggests that more research is required to aid economic policy.

However, there are two main implications from the above analyses. First, most studies favoured specific countries' evidence with different methodologies which have implications for their results. Second, the countries' fundamentals are different and they may be at different stages of development. For instance, Nigeria, a net-oil exporter has considerably increased her energy consumption capacity in a bid to enhance economic growth while South African economy has expanded rapidly due to industrialization. In other to account for these gaps, this study, therefore seeks to undertake a comparative analysis of the relationship between energy consumption and economic growth in Nigeria and South Africa. The study follows the work of Omotor (2007) which is modified to account for the inclusion and comparison with South Africa, as well as the consideration of primary energy components.

The rest of this paper is organized as follows. Following this introduction, section two provides stylized facts of the profile of energy consumption and economic growth indicators in Nigeria and South Africa. Section three covers the literature review with major emphasis on methodology and empirical findings so as to identify gaps in knowledge while section four deals with methodology. The empirical analysis is in section five and section six concludes the study.

2 Profile of Energy Consumption and Economic Growth in Nigeria and South Africa

Nigeria's population is about 167 million while South Africa has a population of 44 million in terms of market size. Economic growth rates in both countries have witnessed wide fluctuation over the years due to external and internal economic and political environment. For instance, Nigeria maintained an average growth of 6% during 1966 and 1975 period largely due to the Dutch oil disease effect before plummeting to a negative growth trajectory in the 1980s. By the end of 1990 and early 2000 decade, the Nigerian economy recovered and has sustained a growth rate of over and above 5.5% average between 2000 and 2008. This was as a result of the sectoral and structural economic reform and policies that have been vigorously pursued under the democratic government since 1999. The government has focused on the non-oil export expansion through the provision of infrastructure to boost external trade particularly the substantial investment in power and steel development.

In South Africa, however, the economy suffered under the political apartheid crisis in the 1980s through early 1990s. Since, the economy assumed a high level of political stability in 1993, the economy has enjoyed a robust economic growth momentum favoured by the high manufacturing base in the automobile industry, information and communication technology as well power and energy. There are several components of energy mix in both Nigeria and South Africa. Nigeria is an oil rich producer in the world while South Africa is known for her sufficient endowment in Coal energy resources. The energy market in Nigeria and South Africa has some modicum of government participation in a market driven economic framework. In terms of general composition, coal, hydro electricity and oil are the main elements of total energy consumption in both economies. For instance, coal shared about 78%, 82% and 118% in 2000, 2005 and 2010 of the total primary energy consumed in South Africa (see, Figure 2). On the other hand, oil consumption accounted for similar proportion in

Nigeria during the same period. The linkages between the total energy consumption and economic growth in Nigeria and South Africa are evident in Figure 1 and 3.

3 Literature Review

Although the relationship between energy consumption and economic growth seems to be well established in the literature, the direction of causality has remained largely unresolved. The literature is replete with diverse evidence on the direction of causality running from energy consumption and economic growth. The divide in the literature is accountable by several factors which include the stage of development of the economies, type of energy component used and methodology adopted by the various authors. In the determination of the sources of growth, capital, and labour as well as other residuals including energy inputs was seen as the main engine of growth as established by the neoclassical growth theory. However, this kind of interaction does not tell us much about causal relationships even though the stage of development could matter.

Mainstream economic analysis on the interaction between energy and economic growth in the literature relates to determining the causal linkage between the variables. This has triggered a strong controversy in the literature as to whether energy consumption leads to economic growth or otherwise. A prominent feature in the literature is the use of diverse methodologies in analyzing this nexus. The original debate started from the seminal paper by Kraft and Kraft (1978) who found a unidirectional relationship from expansion in GNP to energy consumption in the US economy. According to this report, an increase in the GNP causes a substantial expansion in the demand for energy based inputs and resources in the United States.

Similarly, Soytas and Sari (2002) for Italy and Korea, Fatai, Oxley and Scrimgeour (2002) for New Zealand, Ghosh (2002) for India, Yu and Choi (1985) for South Korea, Yang (2000) for Taiwan, Cheng and Lai (1997) in Taiwan Province of India, and Aqeel and Butt (2001) for Pakistan all document a unidirectional causality running from economic growth to energy consumption. Most of these studies utilized the cointegration and error correction method of the granger causality technique (Granger, 1987). This method has been criticized in the econometric literature as highly restrictive and sensitive to the lag selection criteria. Engel and Granger (1987) stated that only series that do not posses long run relationship can be applied to testing the direction of causality between them.

Evidence of unidirectional causality running from increased energy consumption to economic expansion also abound. For example, Yu and Choi (1985) revealed that increase in energy consumption leads to economic growth for South Korea and Philistine but report no causal relationship between energy consumption and economic growth in USA, UK and Poland.

There is also a significant volume of studies that have established bidirectional relationship between economic growth and energy consumption. Glausure and Lee (1977) for South Korea and Singapore; Chang, Fang and Wen (2001) for Taiwan; Soytas and Sari (2002) for Argentina; Jumbe (2004) for Malawi; Ghali and El-Sakka (2004) for Canada; Oh and Lee (2004) for Korea; and Guttormsen for France, Greece, Germany, Italy, Japan, Argentina, India, Indonesia and Philippines; Aqeel and Butt (2001) for Pakistan, Ebohon (1996) for Nigeria and Tanzania, and Omotor (2007) for Nigeria. However, while some studies employed the traditional Granger (1987) method, Omotor (2007) and Aqeel and Butt (2001), utilized the Hsiao's granger technique to evaluate this relationship in a disaggregated data of the energy components. The Hsiao's causality method presumes some advantages over the granger method through its systematic method of lag selection. The method does not equally consider whether variables are of the same order of integration or not as required by the granger theory.

Like other studies, Twerefou, Akoena, Agyire-Tettey and Mawuto (2007) using the vector-autoregressive method revealed that economic growth granger cause energy consumption proxied by electricity and petroleum products consumed for Ghana. This finding is not inconsonance with the results offered by Omotor (2007), who reported a bidirectional relationship between energy consumption disaggregated into (electricity, oil and coal), and economic growth for Nigeria even though both countries appear to be on the same ladder of economic structure and development.

One striking feature of these controversies in the literature draws closely to the methodological implications employed by the various authors. Again, given the varied energy components of countries and the market structures, it is apposite to consider the causal relationship between energy consumption and economic growth in disaggregated manner given that countries have different energy endowments. More also, in a continent like Africa, where Nigeria and South Africa are the leading economic giants in terms of growth, this study intends to investigate the causal relationship between the degree of energy intensity utilization and economic growth using the less restrictive Hsiao's granger causality method.

4 Methodology

A major effort in this study was not to systematically and consistently deviate from the existing order in terms of methodology but to provide a verifiable and acceptable outcome. Basically, this study follows Omotor (2007) and utilized the Hsiao's Granger Causality method to test for the causal relationship between the variables. However, the components of energy mix differ from earlier studies. The choice of this technique is based on the limitation of the Johansen-Co-integration based Granger Causality technique provided below.

4.1 Johansen-Co-integration and Granger Causality

As earlier stated, several methodologies have been applied in the literature but the Engle and Granger (1987) cointegration method has figured prominently. The Johansen test for cointegration and its application in causality test is the main feature of the extended Engel-Granger Representation Theorem which is based on error correction representation of VAR (q) model with a Gaussian error term:

$$\Delta L_t \alpha + \sum_{k=1}^{q-1} \beta_k \Delta L_{t-k} + \delta \Delta L_{t-q} + \mu i \qquad 1$$

Where L_t is an $m \otimes 1$ vector of 1(0) variables (in this case, m=2), β_k and δ are matrices of unknown parameters, and μi is a Gaussian error term.

Equation 1 can be estimated by a maximum likelihood procedure under the hypothesis of a reduced rank $r \prec m$ of δ,

$$G(r) : \delta = -\Gamma\Omega' \qquad 2$$

Where and are matrixes, and as demonstrated by Johansen (1988), that under certain conditions, the rank condition of matrix implies stationarity of . Moreover, the existence of cointegration between the variables implies a framework within which causality can be examined. For instance, Granger (188) has shown that in the presence of cointegration, there must be at least one direction of Granger-causality.

Under the cointegration and causality relationship, the first stage in establishing the existence and direction of causality is to establish the order of integration and the existence or otherwise of cointegration. Depending on the order of integration therefore, three procedures can be used to establish the direction of causality.

If the variables are integrated of order 1, that is 1(1), and cointegrated, the hypothesis of non-causality can be tested at levels of the variables vis-à-vis Equation (3) and (4).

$$LY_t = \alpha + \sum_{i=1}^{k} \lambda_i LY_{t-i} + \sum_{j-1}^{1} \varphi_j LZ_{t-j} + \varepsilon_t \qquad 3$$

$$LZ_t = \psi + \sum_{i=1}^{r} \chi_i LY_{t-i} + \sum_{j-1}^{s} \gamma_j LZ_{t-j} + \eta_t \qquad 4$$

Where the null hypothesis of non-causality is determined by the significance of φ and γ.

If the variables are 1(1) and cointegrated, an alternative form of testing the hypothesis of non-causality is to first- difference the variables (denoted Δ) and add the error-correction term from the cointegrating regression as stated below.

$$\Delta LY_t = \alpha + \sum_{i=1}^{k} \lambda_i \Delta LY_{t-i} + \sum_{j-1}^{1} \varphi_j \Delta LZ_{t-j} + \xi ECM_{t-1} + \varepsilon_t \qquad 5$$

$$\Delta LZ_t = \psi + \sum_{i=1}^{r} \chi_i \Delta LY_{t-i} + \sum_{j-1}^{s} \gamma_j \Delta LZ_{t-j} + \phi ECM_{t-1} + \eta_t \qquad 6$$

In the case of equation (5) and (6), other than the significance of φ and γ, the significance of λ and χ can establish the direction of causality.

Alternatively, if the variables are 1(1) and not cointegrated, the variables must be differenced to establish stationarity as in equation (5) and (6). However, in this case, the test of causality should not include the lagged ECM term:

$$\Delta LY_t = \alpha + \sum_{i=1}^{k} \lambda_i \Delta LY_{t-1} + \sum_{j-1}^{l} \varphi_j \Delta LZ_{t-j} + \varepsilon_t \qquad 7$$

$$\Delta LZ_t = \psi + \sum_{i=1}^{r} \chi_i \Delta LZ_{t-1} + \sum_{j-1}^{s} \gamma_j \Delta LY_{t-j} + \eta_t \qquad 8$$

The initial lags of k, l, r and s are chosen for Equation (3)- (8), using the Akaike information Criteria (AIC). The Wald and LM tests are then used to test the direction of causality.

Some of the drawbacks of the Granger test have been identified in the literature. According to Granger (1968), the Granger test is valid if the variables are not cointegrated. Second, Granger causality results are sensitive to lag length. Thus, if the chosen lag length is more, the irrelevant lags could make the estimates to be inefficient. On the other hand, if the lag length is less than the true lag length, this can cause bias result Ageel and Butt (2003) and Omotor (2007). To circumvent this problem, Hsiao (1981) developed a systematic technique that combines Granger causality and Akaike's Fiscal Prediction Error (FPE), defined as the mean square prediction error. The Hsiao method is a systematic autoregressive approach applied in the choice of optimal lag length for each viable in a model.

4.2 The Hsiao's Granger Causality Method and Procedure

The Hsiao's granger causality technique has been applied in several studies as established in the literature Thornton and Batten (1985), Chang and Lai (1997) Cherg (1995), Ageel and Butt (2001) and Omotor (2007). The Hsiao technique corrects and combines the Granger method in a systematic manner particularly in the choice and selection of lag lengths of the stochastic properties of the data. The main assumption is that variables with different order of integration can tested of their direction of causality. The procedure for testing causality using the Hsiao's method is adapted from Omotor (2007).

Step 1:

We specify a series of autoregressive regressions on the dependent variables. First, the dependent variable is lagged once while in each succeeding regression, one more lag of the dependent variable is added as in equation (9) shown below:

$$d(Y_t) = \alpha + \sum_{i=1}^{p} \beta d(Y_{t-1}) + \varepsilon_{1t} \qquad 9$$

Where $i = 1, \ldots m$, the choice of lag length is based on the sample size and underlying economic process. It is often advisable to select a large m particularly for energy sector that requires a fairly long period of gestation period, a lag length of $m = 8$ can be selected.

Step 2

Compute the Akaike's Fiscal Prediction Error for each regression as in Equation (10) below:

$$FPE(m) = \frac{N+m+1}{N-m-1} ESS^{(m)}/_{N} \qquad 10$$

Where, N is the sample size, m is the lag length and ESS is the sum of squared errors.

Step 3

Obtain the optimal lag length (m^*). The optimal lag length is the lag length that produces the lowest FPE.

Step 4

Estimate the regressions with the lag on the other variable added sequentially in the same manner used to determine the optimal lag length (m^*) as presented in Equation (11) below.

$$d(Y_T) = \alpha \sum_{i=1}^{m^*} \beta d(Y_{t-1}) + \sum_{j=1}^{n} \gamma d(X_{t-j}) + \varepsilon_{2t} \qquad 11$$

where, j ranges from say 1 to 8, as suggested for the other dependent variable.

Step 5

Compute FPE for each regression in Equation (11) as specified in Equation (12) below.

$$FPE(m^*, n^*) = \frac{N + m^* + 1}{N - m^* - 1} ESS^{(m^*, n)} / N \qquad 12$$

Choose the optimal lag length for X, n^* as the lag that produces the lowest FPE.

Step 6

Test for the causality $FPE(m^*)$ which excludes the X variable and compare with $FPE(m^*, n^*)$ which contains the X variable in the model.

Decision Rule:

(a) If $FPE(m^*) \prec FPE(m^*, n^*)$ X_t does not Granger cause Y_t.

(b) If $FPE(m^*) \succ FPE(m^*, n^*)$ X_t Granger causes Y_t.

Note that once the test is performed with Y_t as the dependent variable, a similar test is repeated with X_t as the dependent variable.

4.3 Data

The data used in this study are the various components of energy mix applicable to Nigeria and South Africa. Specifically, the total primary energy components are petroleum (oil), hydro energy and coal that represent energy consumption. The gross domestic product factor cost of 2000 is used to capture economic growth. These data were all collected from the IMF financial statistics 2010 and mainly from the Shell BP statistics and International Energy Association data bank (2011). All the variables were transformed into the natural logarithm.

5 Empirical Analysis

This section presents the results of the empirical investigations. The first subsection considers the statistical properties (unit root and co-integration tests) of the data while the second aspect deals with the Hsiao's causality result.

5.1 Unit Root Tests

Prior to determining whether the variables granger cause each other as well as the direction of causality, the stationarity property of the data and the order of integration was carried out. Both the Augmented Dickey-Fuller and Phillip-Peron test statistics were employed. The results are shown in Table 1a, b. The result indicates that all the variables are stationary. Moreover, only the hydro series for South Africa is stationary at levels while the other variables GDP, COAL, OIL and TOTAL PRIMARY ENERGY are stationary after first difference. Hence, they are integrated of order 1(1). In the case of Nigeria, both the ADF and Phillips-Peron results showed that total primary energy and GDP are stationary after their first difference except total primary energy which was stationary at levels.

5.2 Co-integration Tests Result

Sequel to the observed non-stationarity of the variables or series at levels, the possibility of co-integration between the variables in relation to GDP was investigated. The analysis adopted the Johansen-Juselius (1991) method that is less restrictive in co-integration tests. The result of the co-integration tests are contained in Table 2. Specifically, the results revealed that there is no long-run relationship between total energy consumption and GDP, coal consumption and GDP, and oil consumption and GDP in South Africa and Nigeria for most of the variables. However there is evidence of a weak co-integration between hydro electricity consumption and GDP in South Africa. This therefore, suggests that there is no co-integration between the various components of energy mix and the gross domestic product used to capture economic growth.

5.3 Causality Test Result

Given the focus of this study, the causal relationship between the various components of energy mix, as well as the total primary energy direction with economic growth proxied by GDP were investigated. The analysis is based on the Hsiao's version of the Granger causality technique as modeled in equation 9 and 12. The results are presented in Table 4a,b. Interestingly, the outcome of the co-integration result gave credence on the use of this method. The estimated results showed that economic growth granger causes total primary energy consumption energy in South Africa given that $F(m^*) > F(m^*, n^*)$ while energy consumption granger causes economic growth in Nigeria.

However, the result offered substantial variation when the various components of energy mix were tested for causality in South Africa and Nigeria. For instance, there is a bidirectional relationship between coal consumption and economic growth in South Africa as well as oil consumption and economic growth in Nigeria. Evidently, coal consumption shares over 80% of the total primary energy consumption in South Africa while oil is at heart of energy intensity utilization in Nigeria. Hydro energy equally has a bidirectional relationship with economic growth in Nigeria and South Africa while there is a unidirectional relationship running from oil consumption to economic growth in South Africa. The results further revealed that coal consumption has no causal relationship with economic growth in Nigeria.

These results draws closely from the findings of Ebohon (1996), Yu and Choi (2000) and Omotor (2007). However, there are substantial variation from the evidence offered by Omotor (2007) when compared with Nigeria and South Africa. For example, his study revealed that a bidirectional relationship exists between energy consumption and economic growth which is at variant with the unidirectional relationship suggested in this study.

From the foregoing, the results further illuminate the economic growth fundamentals of these economies. Nigeria as a nation is largely driven by oil production and consumption while South Africa is known for substantial of consumption of coal. More also, these economies have witnessed high economic growth rates. The South African economy is among the emerging markets driven by high manufacturing value added particularly in the automobile industry. Perhaps, apart from the recent boom witnessed in the financial sector, oil and gas industry (energy sector) has remained the mainstay of the Nigerian economy.

6 Conclusion and Policy Recommendation

This study has endevoured to provide additional evidence on the energy consumption and economic growth nexus in Nigeria and South Africa. Nigeria and South Africa are among the fastest growing economies of the world in the African continent. This presupposes that the intensity of energy consumption must be on the same economic growth trajectory. Interestingly, while Nigeria is richly endowed in oil and gas resources, South Africa is known to be among the world's richest country in coal energy resources that constitute large proportion of the overall energy based inputs.

More over, given the continuous debate in the empirical literature on the causal relationship between energy consumption and economic growth, this study offered a reasoned analysis of this nexus using disaggregated energy components of the two countries. The Hsiao's granger causality method was applied for the analysis. The result revealed that economic growth granger causes total primary energy consumption in South Africa while energy consumption and expansion is the driving force to economic growth in Nigeria. It is also evident that economic expansion is the driving force for the high coal consumption while oil consumption appears to be among the critical factors driving economic growth in South Africa. On the hand, oil consumption is the main factor driving economic expansion in Nigeria.

The policy implications from the above analyses are germane. Sub-optimal utilization of energy resources through energy conservative policy may not lead to significant positive effect on economic growth in Nigeria. Thus, policymakers should strive to create conducive environment that would promote industrialization and enhance economic expansion.

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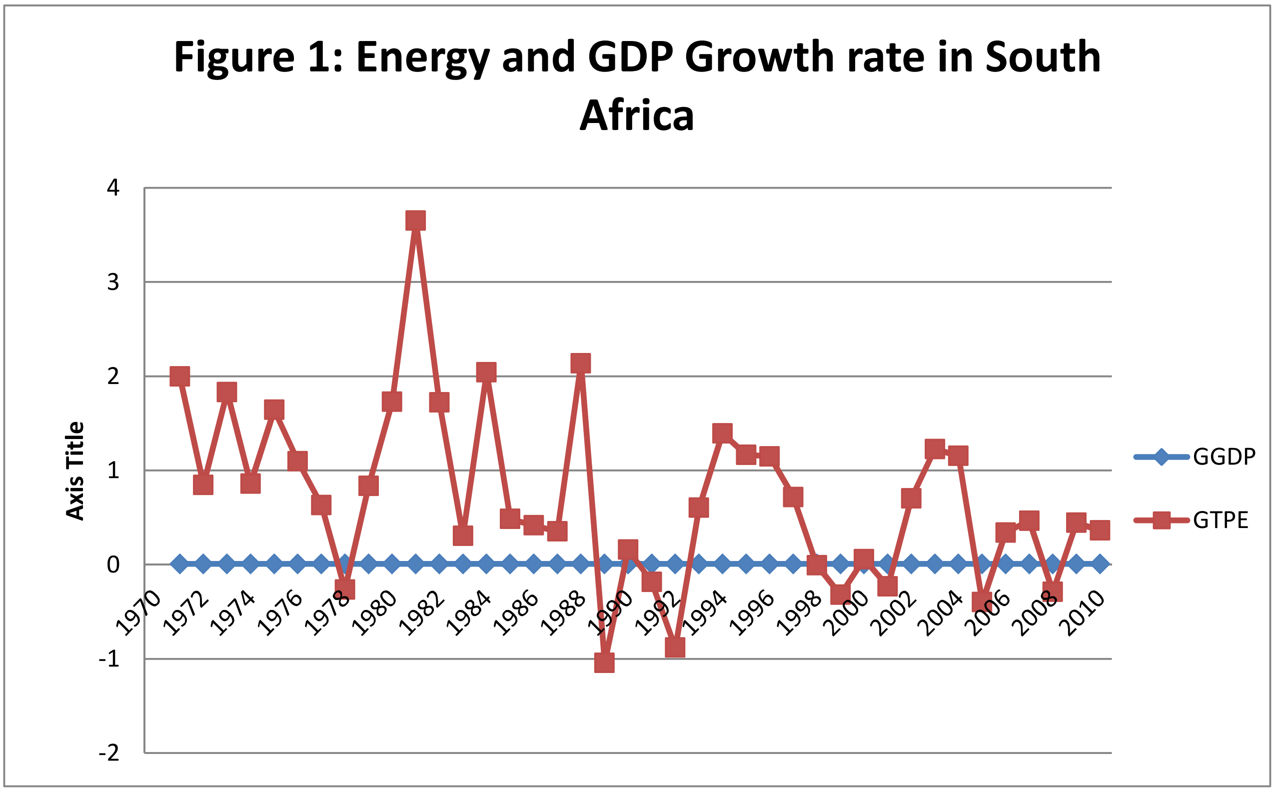
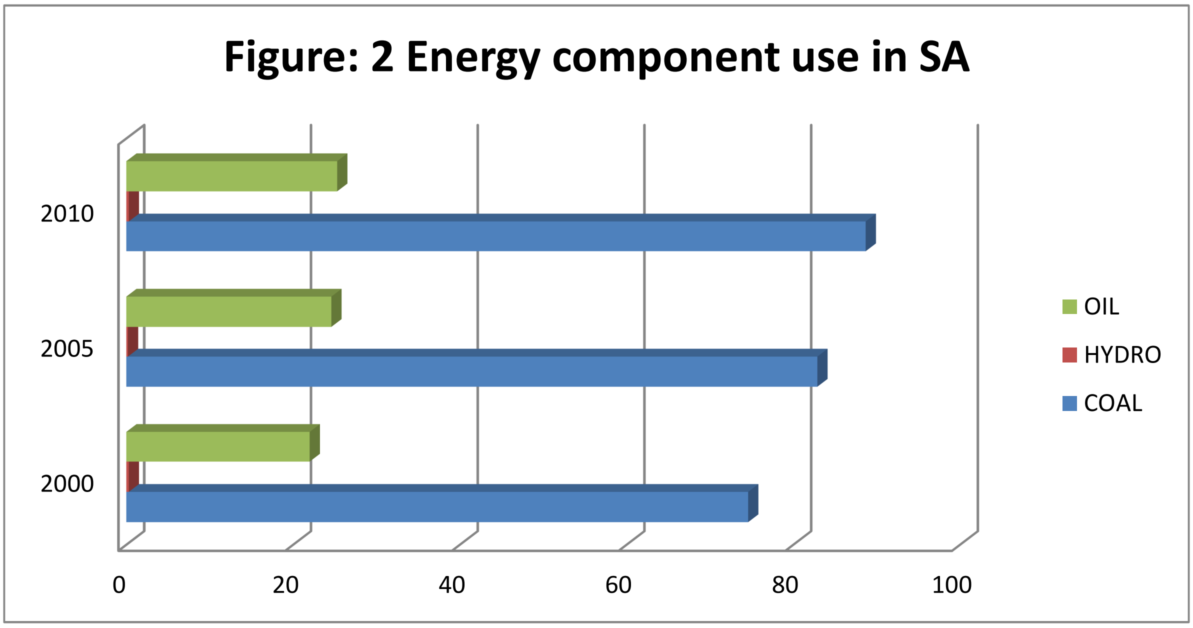
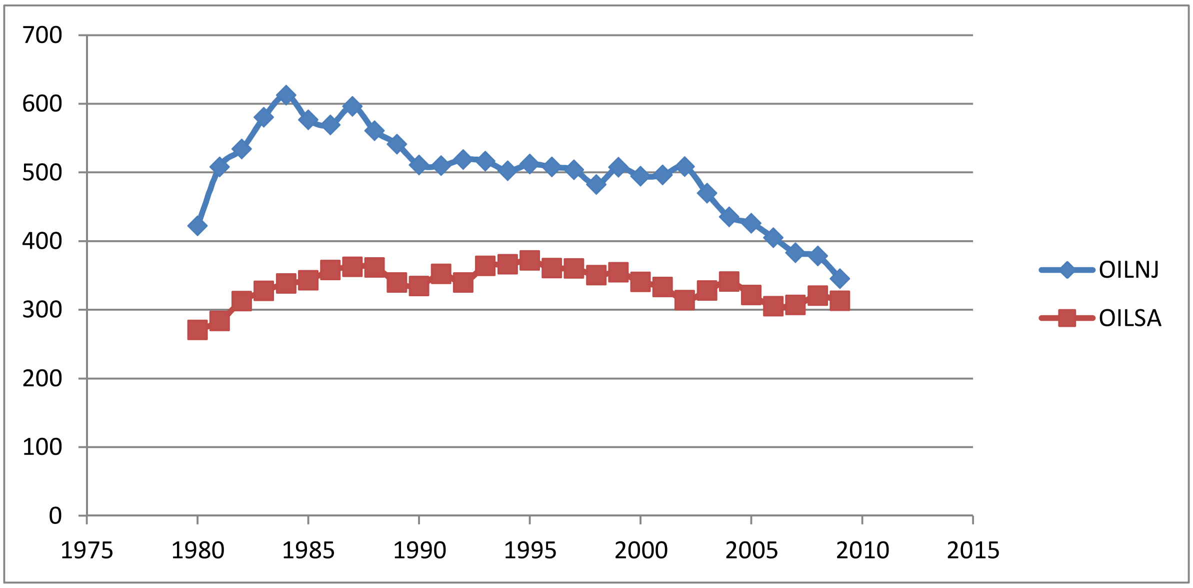


Source: Shell BP statistics 2011



Source: Shell BP 2011

Figure 3: Energy and GDP Growth rate in South Africa



Source: Shell BP 2011

Table 1a: Result of the Unit root tests for South Africa..

	Levels		First Difference	
	ADF	P-P	ADF	P-P
GDP	-2.938987	-2.936942	-2.938987	-2.938987
COAL	-2.936942	-2.936942	-2.938987	-2.938987
HYDRO*	-2.936942	-2.936942	-2.938987	-2.938987
OIL	-2.936942	-2.936942	-2.941145	-2.938987
TPE	-2.936942	-2.936942	-2.938987	-2.938987

Source: Authors' Computation.

Table 1b: Result of the Unit root tests for Nigeria.

	Levels		First Difference	
	ADF	P-P	ADF	P-P
GDP**	-2.941145	-2.941145	-2.943427	-2.943427
COAL*	-2.936942	-2.936942	-2.938987	-2.938987
HYDRO*	-2.936942	-2.936942	-2.938987	-2.938987
OIL*	-2.936942	-2.936942	-2.941145	-2.938987
TPE**	-2.941145	-2.94343	-2.94343	-2.94343

Source: Authors' Computation **significant @ 5%.

Table 2: Results of the Co-integration Tests.

Variables	Nigeria	South Africa
GDP, TPE	***	***
GDP, OIL	***	***
GDP, HYDO	**	* *
GDP, COAL	***	***

Source: Authors' Computation

***** NO Co-integration between the variables**
**** Co-integration exist between the variables**

Table 4a: Results of the Hsiao's Method Causality Tests for South Africa

	F(m*)		F(m*,n*)	Decision rule
The Primary Energy	1.3445×10^{-3} (1)	>	1.3291×10^{-3} (6)	Economic growth causes energy consumption
The GDP Equation	5.0018×10^{-4} (1)	<	5.5813×10^{-4} (4)	Energy consumption does not cause economic growth
The Coal Equation	1.9039×10^{-3} (1)	>	1.2880×10^{-3} (6)	Economic growth cause coal consumption
The GDP Equation	5.0018×10^{-4} (1)	>	4.7994×10^{-4} (4)	Coal consumption cause economic growth
The Hydro Equation	0.4685×10 (6)	>	$0.3627\times$ (4)	Economic growth cause hydro consumption
The GDP Equation economic	5.0018×10^{-4} (1)	>	$4.0337\ \times10^{-4}$ (6)	Hydro consumption cause growth
The Oil Equation	1.0347×10^{-2} (4)	<	$2.3423\times\ 10^{-2}$ (3)	Economic growth does not cause energy consumption

The GDP Equation	5.0018×10^{-4} (1)	> 3.4421×10^{-4} (6)	Oil consumption cause economic growth

Source: Authors Computation. The values in parenthesis are the optimal lags.

Table 4b: Results of the Hsiao's Method Causality Tests for Nigeria

	F(m*)		F(m*,n*)	Decision rule
The Primary Energy	1.2445×10^{-3} (1)	<	1.331×10^{-3} (4)	Economic growth does not cause energy consumption
The GDP Equation	4.3242×10^{-4} (1)	>	3.5813×10^{-4} (6)	Energy consumption causes economic growth
The Coal Equation	1.2019×10^{-3} (1)	<	1.3220×10^{-3} (6)	Economic growth does not causes coal consumption
The GDP Equation	4.3242×10^{-4} (1)	>	3.7994×10^{-4} (3)	Coal consumption cause economic growth
The Hydro Equation	0.4685×10^{-1} (2)	>	0.3326×10^{-1} (5)	Economic growth cause energy consumption
The GDP Equation	4.3242×10^{-4} (1)	>	4.0337×10^{-4} (6)	Hydro consumption cause economic growth
The Oil Equation	2.2047×10^{-2} (4)	>	2.0111×10^{-2} (2)	Economic growth cause energy consumption
The GDP Equation	4.3242×10^{-4} (1)	>	3.4421×10^{-4} (4)	Energy consumption cause economic growth

Source: Authors Computation. The values in parenthesis are the optimal lags.