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Dynamic Effects of Financial Development, Trade Openness and Economic Growth on Energy Consumption: Evidence from South Africa[#]

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ABSTRACT

This paper investigates whether financial development, trade openness and economic growth add to the energy consumption in South Africa and determine what policy guide could be derived with respect to energy consumption vis-à-vis the industrialization process of other African countries for the period of 1970-2011. The unit root properties of the data were examined using the Ng-Perron unit root tests and the traditional structural break unit root tests by Zivot-Andrew was applied. The cointegration properties of the data was observed using the autoregressive distributed lag bounds test approach to cointegration and the Bayer-Hanck combined cointegration test, while the vector error correction method Granger causality approach is applied to examine the causal relationship between the series and this is validated using the innovative accounting approach. Our results show that financial development stimulates energy demand in South Africa; affluence is positively linked with energy consumption, while trade openness also increases energy consumption. We recommend the exploration of several unrestricted energy sources which will sustain the country's leading role as Africa's largest industrial economy, while other rising continents in Africa should note that sustainable energy Granger cause economic growth and thus the secret behind South Africa's leading economic growth prospects.

Keywords: Energy Consumption, Trade Openness, Financial Development, Bayer-Hanck Cointegration, Economic Growth
JEL Classifications: F4, N7, Q43

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1. INTRODUCTION

It has been an established fact that about 14.1% of the world's total population lives in Africa. In spite of this, in 2007 the International Energy Agency (IEA, 2010) reported that African countries consume only 4.2% of the world's delivered energy for industrial use. In line with this assertion and according to the prediction of the IEA, Africa's total industrial energy use and the demand for electricity grow at an average annual rate of 1.4% and 2.6%, respectively, whilst the sub-Saharan African region grows by an average of 3.6% per year. The analysis of the IEA (2010) continued to account that in Africa, the consumption of natural gas, petroleum and other energy allied products has grown substantially in recent years, this being stimulated by the increased economic activity, large investments in new infrastructure, and domestic price subsidies.

The Industrial Development Corporation, IDC (2013) Economic Overview established that, among all the countries of Africa, South Africa has been the leading industrial economy, due largely to its agile, mechanized, and highly diversified economic system that is comparable to none within the Sub-Saharan African region and the entire of Africa. The report continues to assert that, in 2002-2008, the country witnessed a consistent average growth rate of 4.5%, enabling it to supersede its regional counterparts. Similarly, and in a more recent study by Rafindadi and Yusof (2014), the authors established that there are strong relationships between financial development and economic growth in South Africa and that financial development leads to economic development. The question therefore is does the association between financial development and economic growth have a formidable impact on energy consumption of South Africa?

Theoretically there are four views that established the causal relationship between energy consumption and economic growth. The first being, "the growth hypothesis" which established the existence of significant correlation between energy consumption and economic growth irrespective of whether the country is developed or developing, this theory further suggests that economic growth absolutely relies on energy consumption; consequent to this, any procrastination on energy undoubtedly will lead to a commensurate reduction on economic growth. In addition to this, the theory continued to establish that energy may have the tendency to restrict economic growth if concrete efforts were not put to ensure sustainability. The second view, commonly known as "the conservative hypothesis," asserts that there is unidirectional causality between economic growth and energy consumption, adding that energy conservation policies may have minimal impact on economic growth. If an increase in real gross domestic product (GDP) leads to an increase in energy consumption then this supports the conservative hypothesis. The third view, "neutrality hypothesis," suggests that there is no causality between energy consumption and economic growth. The fourth view, "feedback hypothesis," claims that there is a bidirectional causal relationship between energy consumption and economic growth reflecting how they are interdependent and complementary to each other (Ozturk, 2010).

Having regard to the foregoing and considering the mixed result yielded by previous studies, this study aims to investigate empirically the position of the long-run and short-run dynamics of whether financial development adds to energy consumption in South Africa, and to assess the direction of causality by applying the most up to date data and econometric methodology. To further make this study unique, we added in to our analysis the variables of trade openness and affluence, with a view to identifying the explanatory variable(s) responsible for the Granger positioning of financial development, electricity consumption, affluence and trade openness, thereby exposing, whether the secret behind South Africa's economic growth prosperities are partly Granger caused by its energy usage or otherwise. The main intent is that, the direction of our research finding will be used as a policy guide to the rest of the Sub-Saharan African continents struggling to catch up with their economic growth prospects.

The remainder of the paper is organized as follows: Section 2 provides an overview of the recent empirical literature on energy consumption, linking energy consumption to financial development, trade openness and economic growth; Section 3 is the methodology section which introduce the data, the model specification, and the model estimation procedure; Section 4 contains the results and discussion. Finally, Section 5 presents the conclusion and policy recommendations.

2. EMPIRICAL REVIEW

The pioneering work of Kraft and Kraft's (1978) on the nexus between economic growth and energy is still regarded as the leading authority in the field of energy economics. The authors were the first to discover a unidirectional causal relationship between GNP growth and energy usage in the United State in the period from 1947 to 1974. Following to this noble finding, several distinguished researchers like Akarca and Long (1980) made a follow-up investigation with respect to the finding of Kraft and Kraft's (1978), the authors while using different data set and different study periods refuted the finding of unidirectional link between energy and economic growth. This reaction led to the stimulation of early writers to continue the research investigation in the field of energy economics through using different research background. For instance, Erol and Yu (1988) strategically conducted their study from 1952 to 1982 by dichotomizing their case study areas into six world leading industrial nations commonly known to have strong energy consumptions. The findings of their study revealed significant bidirectional causality for Japan. However, a contrasting result was obtained in the case of their findings of Canada which exhibited some tendencies of unidirectional causality from energy to economic growth. Similar non-uniform research findings were also discovered with respect to Germany and Italy which in that period showed that it is economic growth that stimulates energy consumption and surprisingly none for France and England.

Masih and Masih (1996) discovered how energy use piques economic growth in India, and converse was the case with regard to the author's findings in the case of Pakistan and Indonesia. In addition to this, the research discovered that it is economic growth that piques energy consumption in Pakistan and Indonesia, and no causal relationship exist with respect to the findings on Malaysia, Singapore and the Philippines. These degrees of mixed result stimulated Soytas and Sari (2003) to commission their own research investigation by adopting a different research methodology. In their finding, the authors reported that, economic growth Granger cause energy consumption in Italy and South Korea, but the case was different in respect of their findings of Germany, Japan, Turkey and France were the study discovered a simple Unidirectional causality from energy use to economic growth. Similar to this finding, Huang et al. (2008) discovered the absences of any causal link between energy consumption and economic growth in low income countries, rather, it was discovered that there is a unidirectional link from economic growth to energy use in the case of middle and high income countries. This startling findings stimulated early writers like Shahbaz and Lean (2012) Shahbaz and Feridun (2012) to re-study the position of energy consumption and economic growth for Pakistan; Lee (2006) studied the same situation in the case of France, Italy, Japan, and Lee and Chien (2010) for France and Japan again while, Narayan and Smyth (2008), Bowden and Payne (2009) studied Canada, UK, Germany, Sweden, and Switzerland and the G-7 countries. The latter group on the other hand re-studied US. The findings of these authors was summarized to report a mixed result and all contend with fact that there exist no stable and uniform direction of causality among countries which most research findings showed reverse causality particularly as in the study of Lee (2006). The lack of uniformity in the finding of these authors was reported to be attributable to the divergence in econometric methodological application, continental heterogeneity particularly in climatic conditions, time period and accumulated level of economic growth which spells out the direction, utilization and consumption pattern of energy in both industrial and domestic level.

In another development, the linkages between financial development and energy consumptions as according to the empirical findings of Sadorsky (2010; 2011a and b) was established to be resting on the merit that, high level of energy consumption warrant in the significant rise and influx of FDI, improvement in the banking activities which in turn piques the rise and development of the stock market, and other financial infrastructure. These according to the author culminate to enhance national prosperity. Similar in line with the argument put forward by Sadorsky (2010; 2011a and b), Tamazian et al. (2009) asserted that financial development aid in piquing domestic demand which in turn raises energy consumption. While Shahbaz and Lean (2012) on their own part argued that financial development clamps down on CO_2 emissions.

Islam et al. (2013) the authors discovered in the case of Malaysia how financial development enhance economic growth through the use of energy, this together they found it to have an efficient demand boosting mechanism that enabled the economy to remain afloat. The author argued extensively, that financial development enables exuberant purchase of energy appliance which adds to energy demand this in turn piques energy efficiency which cumulatively aid in boosting the performance of the economy. In another dimension Mielnik and Goldemberg (2002) discovered an inverse relationship between FDI and energy intensity (this finding is yet to be ascertain by imminent researchers in the field of energy economics). Corollary to this finding was the research of Tang and Tan (in press) the authors established that the impact of financial development, energy prices and foreign direct investment has a complimentary or feedback effect on the direction of causality to each.

The link between international trade and energy use was investigated by Narayan and Smyth (2009) among others. The authors looked in to the effect of energy consumption, exports, and economic growth using Middle Eastern countries as their case study. The result made no discoveries on the Granger cause between export and energy use. This finding warranted Erkan et al. (2010) to apply an entirely different methodology and re-examined the relationship between energy and export in Turkey. Surprisingly, the outcome of their empirical exercise, showed cointegration between export and energy consumption, they further established that energy consumption Granger cause export. Converse result were however, discovered in the case of Malaysia in the study of Lean and Smyth (2010a and b). In the case of Japan, however, Sami (2011) assessed the impacts of export on energy use. The empirical exercise of the author confirmed unidirectional causality moving from export to economic growth to energy use. Using a panel data approach, Sadorsky (2011b) examined the short-run and long-run Granger causality between export and energy use in the Middle Eastern countries between 1980 and 2007. The findings of the study, showed a dynamic relationship between exports to energy use. The author further argued that a bidirectional feedback effects exist in the short-run and a positive long-run effects were also observed on the variables. The study of Squalli (2007) determined the long-run relationship between energy consumption and economic growth among the OPEC countries. The study underscored the relevance of energy use in enhancing the economic prospects of these continents and further established that depending on the exportation of energy products by these continents is not a sufficient criterion for attaining economic growth. However, there should be a significant need for electricity consumption in countries like Nigeria, Indonesia, Iran, Venezuela and Qatar if an enhanced and sustainable economic growth is to be achieved.

In a more recent study, Rafindadi (2015a) identified how the expanding economic growth prospects of the United Kingdom could pose a threat to its existing energy predicaments by applying dual structural break unit root test and the Bayer and Hanck combined cointegration test. The Findings of the study established that economic growth is negatively linked with energy demand in the United Kingdom while Trade openness was found to have significant positive impacts on the energy consumption of the country. In addition to that, the study discovered how the position of the capital-labour ratio in the United Kingdom to have a composite effect and with significant pressure on the country's energy predicaments. In a related development, Rafindadi (2015b) predicted how the effects of financial development and Trade openness influence the German energy consumption. The findings established the notion that economic growth has a positive influence on the German energy consumption prospects. On the contrary, the study discovered financial development, capital use, and trade openness to have a negative influence on the country's energy demand. The study discovered the existence of the feedback effect between financial development and energy demand; similar direction was discovered between trade openness and energy demand in Germany.

Lin and Wesser (2014) investigate the claims concerning Granger causality relationship from energy consumption to economic growth in South Africa. They adopted a nonparametric bootstrap method to reassess evidence supporting Granger causality and unravel findings of long-run unidirectional causality running from energy consumption to economic growth which implies that energy conservation policies will negatively impact economic growth in South Africa. In the continental African perspective, studies on energy consumption and economic growth were relatively found to be yielding mixed results. For instance, Akinlo (2009) using Nigerian data investigated the causality between energy consumption and economic growth for the periods of 1980-2006. The findings of his study indicated that real GDP and electricity consumption are cointegrated and there is unidirectional Granger causality running from electricity consumption to real GDP. In another similar development, Kouakou (2011) investigated the causal relationship between electric power industry's supply of the country and economic growth of Cote d'Ivoire from 1971 to 2008. The findings reveal bidirectional causality between per capita electricity consumption and per capita GDP in the short run, but a unidirectional causality from electricity to GDP in the long run.

Odhiambo (2009) examines the relationship between energy consumption with economic growth in Tanzania for the period 1971-2006. The study utilizes the Granger causality tests, but unlike Akinlo (2009), the study employs bounds testing approach for cointegration. Furthermore, the author used energy as a proxy of total energy consumption per capita and electricity consumption per capita. The findings of the author established that there is a stable long run relationship between each of the proxies of energy consumption and economic growth. More importantly, the results of the causality test, on the other hand, revealed that there is unidirectional causal flow from total energy consumption to economic growth. Jumbe (2004) examined the relationship between electricity consumption and overall GDP, taking agricultural GDP and non-agricultural GDP of Malawi from 1970 to 1999. The author applied the residual-based cointegration, and the findings of his study suggest that electricity consumption is respectively, cointegrated with GDP of the country and nonagricultural GDP, but not with agricultural GDP. The Granger causality tests suggest bidirectional causality between electricity consumption and GDP, but a unidirectional causality running from non-agricultural GDP to electricity consumption. The author then proceeds to examine the elasticity of the variables this, findings indicates that the impact of electricity consumption is only significant in the long run.

Panel data studies on energy and economic growth that relate to Africa, can be traced to the work of Wolde-Rufael (2006) who used data of 17 African countries for the period 1971-2001 and investigated the long run causal relationship between electricity consumption per capita and real GDP per capita. He applied the bounds test for cointegration; in addition to the causality test proposed by Toda and Yamamoto (1995). The findings reveal unidirectional causality flowing from electricity consumption per capita to real GDP per capita for Benin Congo, DR and Tunisia. On the other hand, the results suggest unidirectional causality flowing from real GDP per capita to electricity consumption per capita for Cameroon, Ghana, Nigeria, Senegal Zambia and Zimbabwe. They also reported bidirectional causality on Egypt, Gabon and Morocco, while no causality on Algeria, Congo Rep. Kenya, Sudan and South Africa. Squalli (2007) reported a contradictory finding to the discoveries of Wolde-Rufael (2006). In his finding, the author noted a unidirectional causality from economic growth to electricity consumption for Algeria; and a bidirectional relationship between economic growth and electricity consumption for Nigeria.

According to the above literature we reviewed, the contributions of this study are as follows:

- In contrast to other researches, this paper investigates whether financial development, trade openness and economic growth could add to energy consumption of the South African economy and if this could be the rationale behind the leading and rising industrialization prospects of the South African economy. From this empirical finding, the study will seek to determine what policy guide could be derived with respect to energy consumption vis-à-vis the industrialization process of the country and other African countries.
- The majority of previous studies have mainly used ADF, PP, DF-GLS, KPSS, and Ng-Perron tests, however, these unit root test are less parsimonious and susceptible to loss of vital information. In addition to this, these test cannot provide the mechanism of dealing with structural breaks stemming in the series, following to this, after checking the stationarity properties of the data using ADF, we proceed to apply the Clement et al. (1998) structural break test to identify possible structural breaks in the series. The Clement et al. (1998) structural break test is widely believed by researchers to be more robust in comparison with the Zivot and Andrew (1992) test.
- We employed Bayer and Hanck (2013) cointegration approach which combines all non-cointegrating tests in establishing a uniform, efficient and reliable cointegration estimates devoid of multiple testing procedures to overcome the likely shortcomings of old existing methods.
- After all these diagnostic analysis, we applied the autoregressive distributed lag (ARDL) bounds testing approach in presence of structural break, due its serial advantages which includes: (i) Its flexibilities and applies regardless the order of integration. Simulation results show that the approach is superior and provides consistent results for small sample (Pesaran and Shin, 1999), (ii) it is dynamic and possesses an unrestricted error correction model (UECM) that can be derived from the ARDL bounds testing through a simple linear transformation. The UECM integrates the short run dynamics with the long run equilibrium without losing any long run information.

3. DATA, MODEL SPECIFICATION AND ESTIMATION PROCEDURE

3.1. Data

The data on energy consumption (kt of oil equivalent), real credit to private sector, real GDP and real trade have been obtained from World Bank (2013) Development Indicators. We have used population series to convert all the variables into per capita terms. The study covers the period of 1970-2011. The main objective of paper is to investigate the relationship between financial development, trade openness, economic growth and energy consumption using South African data. The general form of energy demand function is given as follows:

$$E_t = f(F_t \times Y_t \times TR_t) \qquad (1)$$

We have transformed all the variables into logarithmic form to make the model computable and to also make the data more efficient and reliable in empirical estimation.

3.2. Model Specification

Empirical model specification is give as follows:

$$\ln E_t = \beta_0 + \beta_1 \ln FD_t + \beta_2 \ln Y_t + \beta_3 \ln TR_t + \mu_i \qquad (2)$$

Where, $\ln E_t$ is for natural log of energy consumption (kt of oil equivalent) per capita, $\ln FD_t$ is natural log of real domestic credit to private sector proxy for financial development, economic growth is indicated by $\ln Y_t$ which is natural log of real GDP per capita, $\ln TR_t$ is for natural log of real trade openness per capita (exports + imports) and μ_t is white noise error term. Following to this we can proceed to apply Pesaran et al. (2001) ARDL bounds testing approach. A number of advantages exist to this approach that can be compared to the Johansen cointegration techniques (Johansen and Juselius, 1990). Firstly, a smaller sample size is required to compare it to the Johansen cointegration technique (Ghatak and Siddiki, 2001). Secondly, the ARDL bounds testing approach does not require that the variables be integrated at the same order. The approach can be applied whether the variables are purely I(0) or I(1), or mutually integrated. Thirdly, the approach provides a method of assessing the short- and long-run effects of a variable on another simultaneously, and it also separates the short- and long-run effects (Bentzen and Engsted, 2001).

3.3. Model Estimation Procedure

The ARDL bounds testing approach makes a distinction between the dependent and explanatory variables. In order to implement the bounds testing procedure, (1) is transformed to the unconditional error correction model (UECM) below:

$$\Delta \ln E_t = \vartheta_0 + \sum_{i=1}^{p} \vartheta_i \Delta \ln E_{t-i} + \sum_{i=1}^{p} d_i \Delta \ln F_{t-i} + \sum_{i=1}^{p} d_i \Delta \ln Y_{t-i} \pi_1 + \sum_{i=1}^{p} d_i \Delta \ln TR_{t-i} + \pi_1 \ln E_{t-1} + \pi_2 \ln F_{t-1} + \pi_3 \ln Y_{t-1} + \pi_4 \ln TR_{t-1} + u_{1t} \tag{3}$$

$$\Delta \ln FD_t = \vartheta_0 + \sum_{i=1}^{p} \vartheta_i \Delta \ln FD_{t-i} + \sum_{i=1}^{p} d_i \Delta \ln E_{t-i} + \sum_{i=1}^{p} d_i \Delta \ln Y_{t-i} \pi_1 + \sum_{i=1}^{p} d_i \Delta \ln TR_{t-i} + \pi_1 \ln E_{t-1} + \pi_2 \ln FD_{t-1} + \pi_3 \ln Y_{t-1} + \pi_4 \ln TR_{t-1} + u_{2t} \tag{4}$$

$$\Delta \ln Y_t = \vartheta_0 + \sum_{i=1}^{p} \vartheta_i \Delta \ln Y_{t-i} + \sum_{i=1}^{p} d_i \Delta \ln E_{t-i} + \sum_{i=1}^{p} d_i \Delta \ln FD_{t-i} \pi_1 + \sum_{i=1}^{p} d_i \Delta \ln TR_{t-i} \pi_1 \ln E_{t-1} + \pi_2 \ln FD_{t-1} + \pi_3 \ln Y_{t-1} + \pi_4 \ln TR_{t-1} + u_{3t} \tag{5}$$

$$\Delta \ln TR_t = \vartheta_0 + \sum_{i=1}^{p} \vartheta_i \Delta \ln TR_{t-i} + \sum_{i=1}^{p} d_i \Delta \ln E_{t-i} + \sum_{i=1}^{p} d_i \Delta \ln FD_{t-i} \pi_1 + \sum_{i=1}^{p} d_i \Delta \ln Y_{t-i} + \pi_1 \ln E_{t-1} + \pi_2 \ln FD_{t-1} + \pi_3 \ln Y_{t-1} + \pi_4 \ln TR_{t-1} + u_{3t} \tag{6}$$

Where, Δ denotes the first different operator, the ϑ_0 and d_0 are the drift components, p is the maximum lag length and u_t is the usual white noise residuals. The procedure of the ARDL bounds testing approach has two steps. The first step is a F-test for the joint significance of the lagged-level variables. The null hypothesis for the nonexistence of a long-run relation is denoted by H_0: $\pi_1 = \pi_2 = \pi_3 = \pi_4 = 0$ against H_a: $\pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq 0$. Pesaran et al. (2001) generate lower and upper critical bounds for the F-test. The lower bound's critical values assume that all of the variables are I(0), while the upper bound's critical values assume that all of the variables are I(1). If the F-statistic exceeds the upper critical bound, then the null hypothesis of no cointegration among the variables can be rejected. If the F-statistic falls below the lower bound, then the null hypothesis of no long-run relation is accepted. The next step is the estimation of long-and-short run parameters by using the ECM. To ensure the convergence of the dynamics to long-run equilibrium, the sign of the coefficient for the lagged error correction term (ECM_{t-1}) must be negative and statistically significant. Further, the diagnostic tests comprise the testing for the serial correlation, functional form, normality, and the heteroscedasticity (Pesaran and Pesaran, 2009). Once the variables are cointegrated for the long-run relation, then the long-run as well as short-run causality can be investigated. The existence of a long-run relation between economic growth, financial development, trade openness and energy consumption requires us to detect which direction the causality takes between the variables by applying the vector error correction method (VECM) Granger causality framework. The VECM is as follows:

$$(1-L)\begin{bmatrix} \ln E_t \\ \ln FD_t \\ \ln Y_t \\ \ln TR_t \end{bmatrix} = \begin{bmatrix} \varphi_1 \\ \varphi_2 \\ \varphi_3 \\ \varphi_4 \end{bmatrix} + \sum_{i=1}^{p} (1-L) \begin{bmatrix} a_{11i} & a_{12i} & a_{13i} & a_{14i} \\ b_{21i} & b_{22i} & a_{23i} & a_{34i} \\ a_{31i} & a_{32i} & a_{33i} & a_{34i} \\ a_{41i} & a_{42i} & a_{43i} & a_{44i} \end{bmatrix} + \begin{bmatrix} \xi_1 \\ \xi_2 \\ \xi_3 \\ \xi_4 \end{bmatrix} \times \begin{bmatrix} \ln E_{t-1} \\ \ln FD_{t-1} \\ \ln Y_{t-1} \\ \ln TR_{t-1} \end{bmatrix} \times [ECM_{t-1}] + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \\ \mu_{4t} \end{bmatrix} \tag{7}$$

Where the difference operator is (1−L) and the ECM_{t-1} is generated from long-run relation. The long-run causality is indicated by the significance of the coefficient for the ECM_{t-1} by using the t-test statistic. The F statistic for the first-differenced lagged independent variables is used to test the direction of short-run causality between the variables.

4. RESULTS AND DISCUSSION

First, we provide descriptive statistics and the pair-wise correlations in Table 1: The findings of this table indicate that all the series are white noised and this is confirmed by the Jarque-Bera test statistics. The correlations analysis reveals the existence of positive correlation between financial development and energy consumption. In addition to this, we found economic growth to be positively correlated with energy consumption. In contrast, we found a negative correlation between trade openness and energy consumption. Furthermore, financial development was also found to be positively correlated with economic growth, and the same is true for trade openness and financial development. The correlation between trade openness and economic growth is also found to be positive.

We have applied Clemente-Montanes-Reyes (CMR) structural break unit root with single and two unknown structural break unit root test. We have avoided the traditional unit root tests such as ADF, DF-GLS, PP and KPSS due to their demerits. These unit root tests do have information about structural breaks in the series and provide biased empirical results regarding integrating properties of the variables. We have applied Ng-Perron unit root test which is suitable for small sample data set. This unit root test provides consistent results compared to other traditional unit tests. The results are reported in Table 2. The results show the unit root problem at level with intercept and trend, but all variables are found to be stationary at first difference. This shows that series are found to be integrated at I(1). Ng and Perron (2001) unit root test does not accommodate the structural break point arising in the series.

We have handled this issue by applying CMR unit root test, and results are reported in Table 3. We have applied CMR unit root test accommodating single and two unknown structural breaks in the variables. The results reported by CMR unit root test reveals that all the variables are stationary at first in the presence of single and double unknown structural breaks in the series.

As the unit root test shows that all variables follow the I(1), the combined cointegration tests are proceeded. Table 4 illustrates the VAR Order selection criteria results for the LR, Final prediction error, Akaike information criterion (AIC), SC and HQ that are used. On the basis of the result, we follow AIC criteria and 1 is our required lag length.

To find the cointegration among the variables, we have applied the ARDL bounds testing approach to cointegration in the presence of structural breaks in the series (See Rafindadi (2016a), Rafindadi and Ozturk (2016b), Rafindadi (2016c) and Rafindadi and Ozturk (2016d). Now we compute ARDL F-statistic to make a decision whether cointegration exists between the variables. The results are reported in Table 5. We find that our calculated F-statistics exceed upper critical bounds at 5% and 1% levels respectively once we use energy consumption and financial development as dependent variables. This confirms the presence of cointegration among the variables. The cointegration is present in the presence of structural breaks in the series over the period of 1970-2011. We may conclude that there is long-run relationship among financial development, energy consumption, economic growth and trade openness in the case of South Africa. In the presence of cointegration, now we can find the long-run impact of financial development, economic growth and trade openness on energy consumption and the results are reported in Table 5.

The results of Bayer-Hanck combined cointegration approach reveal that our calculated values of EG-JOH and EG-JOH-BO-BDM are greater than critical values provided by Bayer and Hanck (2013) (Table 6). This indicates that we may reject the hypothesis of no cointegration at 1 percent level of significance once we used energy consumption, economic growth and trade openness as forcing variables. We conclude that there is long-run relationship among the variables, and our long run results are robust and reliable.

Table 1: Descriptive statistics and correlation matrix

Variable	lnE_t	$lnFD_t$	lnY_t	$lnTR_t$
Mean	7.8266	10.2815	10.3677	9.5585
Median	7.8610	10.1187	10.3606	9.5885
Maximum	7.9657	11.0215	10.5237	9.9988
Minimum	7.5752	9.5346	10.2556	9.2570
SD	0.1102	0.3904	0.0722	0.1883
Skewness	−0.8415	0.4370	0.4846	0.3853
Kurtosis	2.5397	2.0985	2.4317	2.7999
Jarque-Bera	4.3284	2.7590	2.2089	1.1095
P	0.1696	0.2517	0.3313	0.5741
lnE_t	1.0000			
$lnFD_t$	0.4761	1.0000		
lnY_t	0.2459	0.3062	1.0000	
$lnTR_t$	−0.0851	0.6790	0.4261	1.0000

SD: Standard deviation

Table 2: Ng-Perron unit root test

Variables	MZa	MZt	MSB	MPT
lnE_t	−3.84155	−1.3693	0.3564	23.4937
ΔlnE_t	−19.9737**	−3.1593	0.1581	4.5672
$lnFD_t$	−13.4313	−2.5476	0.1896	7.0314
$\Delta lnFD_t$	−26.5479*	−3.6428	0.1372	3.4351
lnY_t	−8.92618	−2.0273	0.2271	10.5209
ΔlnY_t	−21.6160**	−3.2842	0.1519	4.2358
$lnTR_t$	−8.66129	−2.0733	0.2393	10.5475
$\Delta lnTR_t$	−18.3501**	−2.9453	0.1605	5.4659

* and ** represent significance at 1% and 5% respectively

Table 3: Clemente-Montanes-Reyes detrended structural break unit root test

Model: Trend break model								
Variable	Innovative outliers				Additive outlier			
Series	T_{B1}	T_{B2}	Test statistics	K	T_{B1}	T_{B2}	Test statistics	K
lnE_t	1979	-	−2.783	2	1983	-	−6.238*	2
	1979	1987	−3.300	3	1983	2001	−7.218*	3
$lnFD_t$	1990	-	−4.190	2	1990	-	−9.086*	3
	1990	2004	−1.551	3	1990	1994	−12.658*	1
lnY_t	1983	-	−1.590	1	2000	-	−4.371**	4
	1983	2003	−4.440	2	1983	2003	−5.833**	3
$lnTR_t$	1999	-	−2.698	2	1984	-	−4.798**	3
	1993	2003	−2.712	2	1984	2000	−5.728**	4

T_{B1} and T_{B2} are the dates of the structural breaks; k is the lag length, * and ** show significant at 1% and 5% levels respectively

It is pointed by Pesavento (2004) that respective cointegration approaches are sensitive with the value of nuisance estimators. To overcome this issue, we applied the latest methodology developed by Bayer and Hanck (2013) which combined the efficiencies of all non-cointegrating tests to obtain uniform and reliable cointegration results. This cointegration test provides efficient estimates by ignoring the nature of multiple testing procedures. This implies that the application of non-combining cointegration tests provide robust and efficient results compared to individual t-test or system based test. So, Bayer and Hanck (2013) followed Fisher (1932) formula to combine the statistical significance level i.e., P-values of single cointegration test and formula is given below:

$$EG\text{-}JOH = -2[\ln(P_{EG})+\ln P_{JOH}] \quad (8)$$

Table 4: Lag length selection

VAR lag order selection criteria						
Lag	**LogL**	**LR**	**FPE**	**AIC**	**SC**	**HQ**
0	109.1088	NA	5.36e-08	−5.390196	−5.219574	−5.328978
1	277.1603	293.0128*	2.21e-11*	−13.18771*	−12.33460*	−12.88162*
2	285.0738	12.17470	3.45e-11	−12.77302	−11.23742	−12.22206
3	294.1445	12.09424	5.29e-11	−12.41767	−10.19959	−11.62184

*Indicates lag order selected by the criterion, LR: Sequential modified LR test statistic (each test at 5% level), FPE: Final prediction error, AIC: Akaike information criterion SC: Schwarz information criterion HQ: Hannan-Quinn information criterion

$$EG\text{-}JOH\text{-}BO\text{-}BDM = -2[\ln(P_{EG})+\ln(P_{JOH})+\ln(P_{BO})+\ln(P_{BDM})] \quad (9)$$

The probability values of different individual cointegration tests such as Engle and Granger (1987); Johansen (1995); Boswijk (1994); Banerjee et al. (1998) are shown by P_{EG}, P_{JOH}, P_{BO}, and P_{BDM} respectively. To take decision whether cointegration exists or not between the variables, we follow Fisher statistic. We may conclude in favor of cointegration by rejecting null hypothesis of no cointegration once critical values generated by Bayer and Hanck are less than calculated Fisher statistics and vice versa. In the presence of cointegration, now we can find long run impact of financial development, economic growth and trade openness on energy consumption and results are reported in Table 7.

The results show that financial development has a positive and significant effect on energy consumption. The results highlighted that a 0.1% increase in financial development increases energy consumption by 0.26%, keeping other things constant. These findings are consistent with existing studies such as Islam et al. (2013), Shahbaz et al. (2013) and Mudakkar et al. (2013) for Pakistan, Malaysia and China, respectively. However, this finding is in contrast with the research findings of Wolde-Rufael (2006). The findings of our research further suggest that economic growth add7.536 pt

s to energy consumption and it is statistically significant at a 1% level of significance. A 0.1% increase in economic growth leads energy demand by 0.46, all else is the same. This empirical evidence supports the view reported by Shahbaz et al. (2012) who noted that economic growth stimulates energy consumption. The relationship between trade openness and energy consumption is negative, and it is statistically significant at a 1% significance level. This finding is contradictory to Sadorsky (2011b; 2012) who reported that trade openness increases energy consumption. Furthermore, our long-run model fulfills the assumption of the classical linear regression model. We find the evidence of a normal distribution of error term. There is no issue of serial correlation, and the same conclusion goes for ARCH test. The residual term is homoscedastic, and the functional form of the long-run model is well constituted.

The results of short-run dynamics are presented in Table 8. The results show that financial development has a negative and statistically insignificant impact on energy consumption. The coefficient of financial development shows that a 0.1% increase in financial development insignificantly decreases energy consumption by 0.01%. The effect of economic growth on energy consumption is positive and statistically significant. Keeping other things constant, a 0.35% energy consumption is linked with a 1% increase in economic growth. Trade openness has a positive relationship with energy consumption, but it is statistically insignificant.

Table 5: ARDL cointegration test results

Variables	$\ln E_t$	$\ln FD_t$	$\ln Y_t$	$\ln TR_t$
Break year	1979	1990	1983	1999
F-statistic	6.533**	6.648**	3.4393	3.3130
Critical values	1% level	5% level	10% level	
Lower bounds	7.133	5.130	4.300[a]	
Upper bounds	7.820	5.780	4.780	
R^2	0.5509	0.7974	0.8379	0.8343
Adjusted R^2	0.3175	0.6221	0.7536	0.7473
F-statistics	2.3598**	7.5709*	3.563**	9.663*

*,** show the significance at 1%, 5% level respectively. [a]Critical values bounds are from Narayan (2005) with restricted trend and unrestricted intercept, ARDL: Autoregressive distributed lag

Table 6: The results of Bayer and Hanck cointegration analysis

Estimated models	EG-JOH	EG-JOH-BO-BDM	Cointegration
E_t=f (FD_t, Y_t, TR_t)	3.0765	16.1232	None
FD_t=f (E_t, Y_t, TR_t)	56.8189*	65.6566	✓
TR_t=f (E_t, FD_t, TR_t)	2.1650	4.1075	None
TR_t=f (E_t, FD_t, Y_t)	3.5050	5.1725	None

*Represents significant at 1% level. Critical values at 1% level are 16.259 (EG-JOH) and 31.169 (EG-JOH-BO-BDM) respectively

Table 7: Long-run analysis

Dependent variable=$\ln E_t$				
Variables	**Coefficient**	**T-statistic**	**Coefficient**	**T-statistic**
Constant	5.0168*	1.5756	3.1840	0.0029
$\ln FD_t$	0.2630*	0.0391	6.7240	0.0000
$\ln Y_t$	0.4620*	0.1676	2.7558	0.0090
$\ln TR_t$	−0.4899*	0.0854	−5.7331	0.0000
R^2	0.5879			
Adjusted-R^2	0.5445			
F-statistic	17.5957*			

Diagnostic tests		
Test	**F-statistic**	**P value**
χ^2 NORMAL	1.1944	0.5503
χ^2 SERIAL	0.6517	0.3900
χ^2 ARCH	0.5887	0.3977
χ^2 WHITE	0.0189	0.9918
χ^2 REMSAY	1.9631	0.2545

*Shows significance at 1% level

Table 8: Short-run analysis

Dependent variable = ΔlnE_t				
Variables	**Coefficient**	**T-statistic**	**Coefficient**	**T-statistic**
$Constan_t$	0.0080	0.0054	1.4917	0.1447
$\Delta lnFD_t$	−0.0110	0.0374	−0.2956	0.7692
ΔlnY_t	0.3516**	0.1698	2.0709	0.0458
$\Delta lnTR_t$	0.0085	0.0830	0.1025	0.9189
ECM_{t-1}	−0.2414*	0.0770	−3.1339	0.0035
R^2	0.2694			
Adjusted-R^2	0.1859			
F-statistic	3.2272**			
Diagnostic tests				
Test		**F-statistic**		**P value**
χ^2 NORMAL		0.9995		0.6066
χ^2 SERIAL		1.0108		0.3749
χ^2 ARCH		0.5887		0.3977
χ^2 WHITE		0.0189		0.9918
χ^2 REMSAY		2.8437		0.1075

*, ** Shows significance at 1% and 5% level respectively

Table 9: The VECM Granger causality analysis

Variables	Direction of Granger causality				
	Short run				Long run
	ΔlnE_t	$\Delta lnFD_t$	ΔlnY_t	$\Delta lnTR_t$	ECT_{t-1}
ΔlnE_{t-1}	…	0.2283	1.3449	0.3059	−0.2568**
		(0.7972)	(0.2749)	(0.7386)	(−2.3513)
$\Delta lnFD_{t-1}$	0.1793	…	0.4872	0.6304	−0.3764***
	(0.8366)		(0.6189)	(0.5391)	(−1.7206)
ΔlnY_{t-1}	0.3026	1.1863	…	24.1542*	…
	(0.7610)	(0.3184)		(0.0000)	
$\Delta lnTR_{t-1}$	0.1412	1.2071	20.2338*	…	…
	(0.8868)	(0.3123)	(0.0000)		

*.** and *** represent significance at 1%, 5% and 10% levels respectively, VECM: Vector error correction method

The estimate of ECM_{t-1} is negative and statistically significant. The lagged of ECM is equivalent to −0.2414. The negative value of ECM is theoretically correct which shows the speed of convergence from short-run towards long-run. It implies that short-run variations are corrected by 24.14% every year. The significance of the lagged error term further confirms our ascertained long-run relationship between the variables. The short-run model also provides satisfactory results of diagnostic tests. We note that the error term is white noised. There is an absence of serial correlation and the same is true for autoregressive conditional heteroskedasticity. There is no issue of white heteroskedasticity, and functional form is well constructed. The stability of the model is necessary and to investigate the stability of the model, we apply cumulative sum (CUSUM) and the CUSUM of the squares (CUSUM sq). The stability test explains that the estimated model of energy demand is stable over the study period.

The estimated graphs of the CUSUM and the CUSUM sq are presented in Figures 1 and 2. The ARDL bound testing method is used to find the CUSUM and CUSUM sq tests. The results are shown in Figures 1 and 2. The plots of the CUSUM statistics and CUSUM sq tests are well within the critical bounds. This shows that our estimated model is a good fit. In Figures 1 and 2 the straight lines represent critical bounds at 5% significance level.

Figure 1: Plot of cumulative sum of recursive residuals

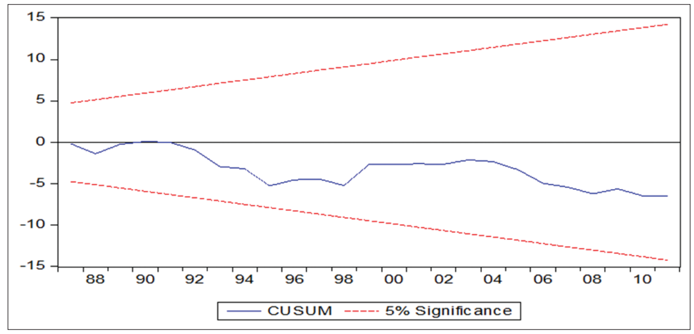


Figure 2: Plot of cumulative sum of squares of recursive residuals

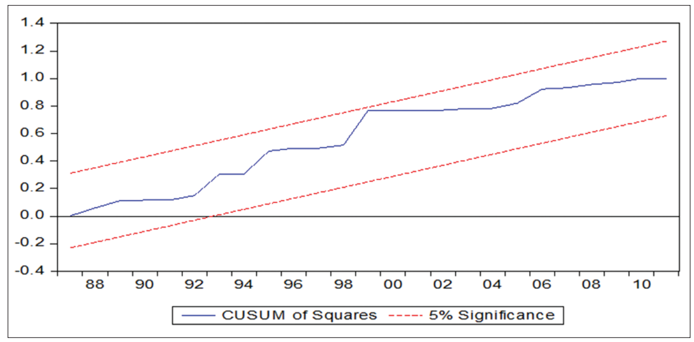


Table 9 shows the results of the VECM Granger causality analysis. These show in the long-run, Granger causality analysis reveals the feedback effect between energy consumption and financial development i.e., energy consumption Granger causes financial development and financial development Granger causes energy consumption. The demand-side hypothesis is validated as economic growth Granger causes financial development. Financial development and energy consumption are Granger cause of trade openness. Economic growth Granger causes trade openness and trade openness Granger cause economic in the short-run.

The extent of causality relationship between the variables can be determined by applying the innovative accounting i.e., variance decomposition and impulse response function. Table 10 shows the results of variance decomposition approach. We find that energy consumption is explained by 25.37%, 23.90% and 3. 83% due innovative shocks occur in financial development, economic growth and trade openness and rest is 46.88% is explained by innovative shocks in energy consumption. Energy consumption, economic growth and trade openness contribute to financial development by 35.14%, 21.38% and 8.28% respectively. A 35.14% of financial development is contributed by its innovative shocks.

The contribution of energy consumption, financial development and trade openness is 11.41%, 7.85% and 15.90% respectively. Trade openness is contributed by energy consumption, financial development and economic growth by 8.10%, 4.31%, and 66.79% respectively. A 20.78% of trade openness is contributed by its innovative shocks. Overall, we find the bidirectional causality between energy consumption and financial development. Economic growth causes energy consumption, financial development and trade openness.

Table 10: Variance decomposition approach

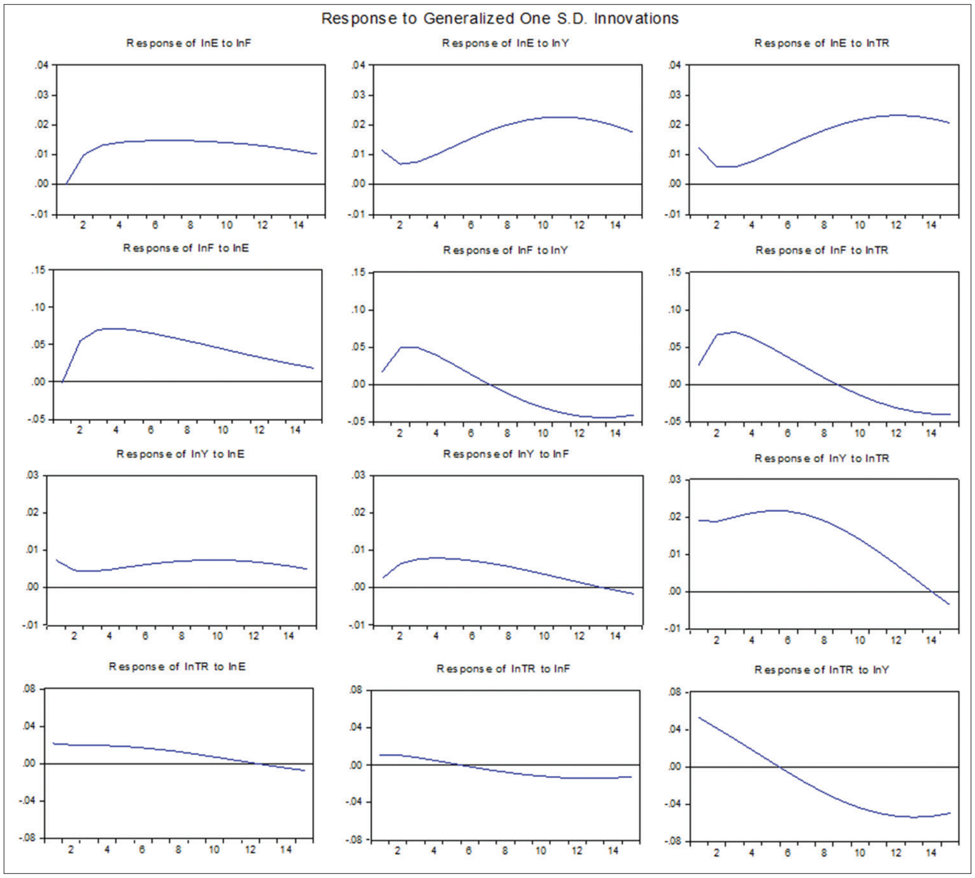
Period	lnE_t	$lnFD_t$	lnY_t	$lnTR_t$
Variance decomposition of lnE_t				
1	100.0000	0.0000	0.0000	0.0000
2	93.2540	5.2947	0.2173	1.2338
3	86.2427	11.1390	0.1674	2.4506
4	80.3834	15.9528	0.4621	3.2015
5	75.2664	19.6601	1.5877	3.4856
6	70.5280	22.3900	3.6679	3.4139
7	66.0575	24.2810	6.5313	3.1300
8	61.9039	25.4783	9.8418	2.7758
9	58.1697	26.1343	13.2276	2.4682
10	54.9446	26.3961	16.3721	2.2871
11	52.2778	26.3923	19.0551	2.2747
12	50.1761	26.2255	21.1562	2.4420
13	48.6129	25.9702	22.6390	2.7776
14	47.5380	25.6774	23.5300	3.2545
15	46.8861	25.3772	23.9004	3.8361
Variance decomposition of $lnFD_t$				
1	0.0016	99.9984	0.0000	0.0000
2	9.2691	86.6079	1.5545	2.5682
3	18.5721	73.9203	2.2118	5.2956
4	25.4048	65.1483	2.0826	7.3642
5	30.2769	59.1032	1.8170	8.8027
6	33.7422	54.6596	1.8887	9.7094
7	36.1222	51.1395	2.5753	10.1629
8	37.6062	48.1681	3.9847	10.2408
9	38.3386	45.5517	6.0752	10.0343
10	38.4625	43.2034	8.6851	9.6488
11	38.1316	41.0963	11.5787	9.1931
12	37.5021	39.2326	14.4991	8.7659
13	36.7188	37.6232	17.2140	8.4438
14	35.9018	36.2760	19.5460	8.2760
15	35.1401	35.1903	21.3863	8.2831
Variance decomposition of lnY_t				
1	10.6237	1.3443	88.0319	0.0000
2	7.48987	4.9000	87.5855	0.0245
3	6.1527	7.1015	86.4409	0.3047
4	5.6786	8.2858	85.0566	0.9787
5	5.6898	8.8825	83.3879	2.0396
6	6.0091	9.1494	81.4114	3.4300
7	6.5409	9.2261	79.1532	5.0796
8	7.2236	9.1877	76.6772	6.9113
9	8.0060	9.0761	74.0813	8.8364
10	8.8351	8.9157	71.5002	10.7488
11	9.6494	8.7225	69.1037	12.5243
12	10.3788	8.5089	67.0837	14.0283
13	10.9519	8.2860	65.6250	15.1369
14	11.3091	8.0646	64.8600	15.7661
15	11.4192	7.8541	64.8254	15.9012
Variance decomposition of $lnTR_t$				
1	12.3075	3.2452	58.0940	26.3531
2	13.1895	3.6423	52.2481	30.9199
3	14.5343	3.5932	46.1598	35.7124
4	15.9973	3.3260	40.4919	40.1845
5	17.2439	2.9998	36.1331	43.6230
6	17.9491	2.7373	34.0172	45.2962
7	17.8879	2.6250	34.7275	44.7595
8	17.0415	2.6940	38.1289	42.1355
9	15.6101	2.9151	43.3712	38.1034
10	13.9068	3.2220	49.2970	33.5740
11	12.2204	3.5456	54.9102	29.3237
12	10.7410	3.8354	59.6024	25.8210
13	9.5568	4.0646	63.1298	23.2485
14	8.6851	4.2241	65.4885	21.6021
15	8.1039	4.3161	66.7979	20.7820

The results of impulse response function are shown in Figure 3. The results show that energy consumption responds positively due to forecast error which arises in financial development, economic growth and trade openness respectively. The response of financial development goes down after 7th and 9th time horizons in economic growth and trade openness. Economic growth responds positively due to energy consumption forecast error but response of economic growth becomes negative after 14th time horizon in financial development and trade openness. Trade openness responds negatively after 11th and 7th (7th) time horizons in energy consumption and financial development (economic growth) respectively.

5. CONCLUSION AND POLICY IMPLICATIONS

This paper explores the dynamic relationship between financial development, trade openness, affluence, and energy consumption using time series data of South Africa from 1970 to 2011. This is done with the aim of identifying if economic growth, trade openness, and financial development could add to the dynamics of energy consumption in South Africa. From this development, the study seeks to determine a policy guide for the country and to draw a lesson for the rest of the African continents considering South Africa as the leading mechanized economy in the whole of Africa. In doing so, the unit root properties of the data was examined using the Ng-Perron unit root tests in addition to this, the traditional structural break unit root tests by Zivot-Andrew was applied. The cointegration properties of the data was observed using the ARDL bounds test approach to cointegration and the Bayer-Hank combined cointegration test, while the VECM Granger causality analysis is applied to examine the causal relationship between the series and this is validated using the innovative accounting approach. Our results confirm the existence of cointegration relationship among the variables. Following to this, the study discovered that financial development stimulates energy demand in South Africa. This means that financial development can have significant impacts on the creation of energy infrastructure such that it aids in the holistic development of efficient energy usage, among other things. As a result of this, we argue that, a priori, developed financial infrastructure should flavour efficient energy use in South Africa. In another line of development, the study found affluence and trade openness to be strong candidate that increases energy consumption in South Africa. Apart from that, we further discovered the existence of long-run and short-run correlation between energy consumption and GDP with a strong interdependence. By this finding it means that the greater the energy consumption in South Africa the higher will be the economic growth prospects of the country and the better up will be the level of affluence of the country's population. Following from this, and in order for the population to continue in a sustainable level of affluence, we argue for strong commitment by the South African policy makers on investments in renewable sources of energy in order to guard against CO_2 emissions that are likely to increase with the corresponding increase in energy consumption.

Figure 3: Impulse response function



As a policy implication, this study argue that South African energy policy makers should embrace alternative long-run methods of energy saving such as mitigation options and the adoption of several energy mix strategies. This is with a view to curve out energy shortage and other inefficiencies that may jeopardize present and potential level of economic growth and affluence attained in the country. This situation may require the necessary steps of adopting financial development strategies that will in turn open up for massive investment into sustainable form of energy infrastructure into the country. Failure to ensure this will lead to the decline in energy supply which will in turn lead to the deterioration in both affluence and the economic growth prospects of the country. To support our claim on this point raised, the study discovered that a 0.1% increase in financial development tend to lead to an increase in energy consumption by 0.26% in the long-run, keeping other things constant. The study further discovered that a 0.35% increase in energy consumption is linked to a 1% rise in economic growth. Furthermore, we found in this study that trade openness Granger causes energy demand, i.e., the trade-led energy hypothesis, and there is a unidirectional causality from economic growth to financial development, and this validates the existence of demand-side hypothesis in South Africa. Following to this evidence of unidirectional causality and despite the existence of mixed results, we insist for massive investment in to the South African energy sector as the most crucial factor that could salvage the country's economy from imminent deterioration in GDP.

As a conclusion, we argue that for sustainable economic development to be attained by any African country, the crucial role of energy should foremost be recognized as the only modern life wire that is responsible in ensuring sustainable and strategic economic growth prospects. In this respect, African countries should note that sound energy policies backed by strong commitment towards achieving an efficient and realistic energy reserves should be their overarching prerequisite and guiding principles if these continents are to achieve realistic economic growth. This is in the sense that in international trade, economic production, education, health, communications, increase in industrial output, effective transportation services, and better delivery of healthcare services, as well as increase in food production and the provision of sufficient shelter for the populace are all associated with higher levels of energy consumption, meaning to say that their efficient and effective operation has no close substitute to energy whatsoever. As a result, South Africa and the rest of the African region should adopt special care in the provision of the requisite infrastructure and environment that must be precursors to policies relating to financial development and energy use and vice versa.

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