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Sectoral Energy Consumption in South Africa and Its Implication for Economic Growth

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***Abstract*—**South Africa is in its post-industrial era moving from the primary and secondary sector to the tertiary sector. The study investigated the impact of the disaggregated energy consumption (coal, oil, and electricity) on the primary, secondary and tertiary sectors of the economy between 1980 and 2012 in South Africa. Using vector error correction model, it was established that South Africa is an energy dependent economy, and that energy (especially electricity and oil) is a limiting factor of growth. This implies that implementation of energy conservation policies may hamper economic growth. Output growth is significantly outpacing energy supply, which has necessitated load shedding. To meet up the excess energy demand, there is a need to increase the generating capacity which will necessitate increased investment in the electricity sector as well as strategic steps to increase oil production. There is also need to explore more renewable energy sources, in order to meet the growing energy demand without compromising growth and environmental sustainability. Policy makers should also pursue energy efficiency policies especially at sectoral level of the economy.

***Keywords*—**Causality, economic growth, energy consumption, hypothesis, sectoral output.

I. Introduction

INADEQUATE supplies of energy resources to meet demand and the need for environmental conservation affect growth which has propelled countries to find a middle ground between energy consumption and economic growth [1], [2]. Reference [3] suggested that the saving of energy in the industrial, agricultural, service and housing sectors may be necessary if it helps in reducing energy cost, price of goods and services, green-house gas emission and also leads to better resource allocation by shifting capital and labor from the energy sector to more productive sectors. However, if production depends heavily on energy resources (as in the case of South Africa); energy conservation policy may put a constraint on economic growth. It is argued that decreasing energy consumption may reduce economic growth and increase unemployment since energy is considered as essential factor of production [4]. This presents countries with the dilemma of either promoting energy-saving policy at the expense of economic growth or vice versa. Empirical investigation as to whether energy consumption is a consequence or cause of economic growth is therefore essential [5].

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The implication of energy scarcity for future economic growth raises wider issues since much of the argument of "time discounting" depends crucially on the proposition that the future will be more prosperous than the present. The response of higher energy demand due to changes in lifestyle and level of technology in South Africa will affect not only the future standard of living of South Africans but also influence the nature and extent of economic growth in the country. Also, most studies [6]–[8] on the relationship between energy consumption and growth, including the ones that examined that the various energy types (coal, crude oil, natural gas and electricity), have only focused on the aggregate economy. However, since the energy intense sectors constitute the entire economy, examining the impact of energy consumption on sectoral (primary, secondary and tertiary) economic growth tends to give new insights on the impact of sector based energy consumption on growth.

The knowledge of the dynamic interaction between energy consumption and economic growth in South Africa plays a crucial role in the design and implementation of energy policies. If, for instance, a decrease in energy consumption hampers economic growth, then adopting energy conserving policies designed to reduce energy consumption will not be desirable. On the other hand, if reducing energy consumption does not affect economic growth, energy conserving policies may be implemented without adversely affecting economic growth. To this end, this study investigated the impact of the energy components (coal, oil, and electricity) on the primary, secondary and tertiary sectors of the economy between 1980 and 2012 in South Africa.

The remaining parts of this paper are as follows: Section II presents a brief account of the South African energy sector, Section III reviews related literature, Sections IV discusses methodology and data, Section V focuses on the results and discussions, while Section VI gives the summary and policy implications.

II. A Brief Account of the South African Economy and Energy Sector

South Africa's energy sector is critical to its economy due to the fact that the economy has a strong natural resource base and a variety of energy options. Coal is a major primary energy source in South Africa. In 2012, about 72 percent of South Africa's total primary energy consumption came from coal, followed by crude oil (22 percent), natural gas (3 percent), nuclear (3 percent), while renewables (primarily from hydropower) contribute less than 1 percent (Fig. 1).

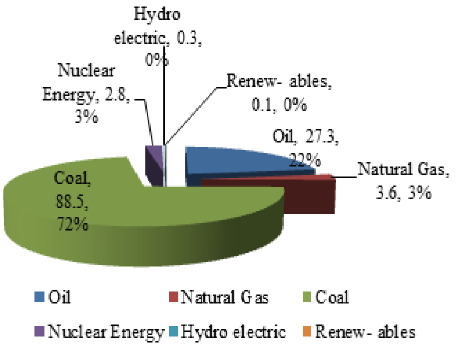

Fig. 1 Total Primary Energy Consumption by Fuel Type in South Africa (2012) [35]

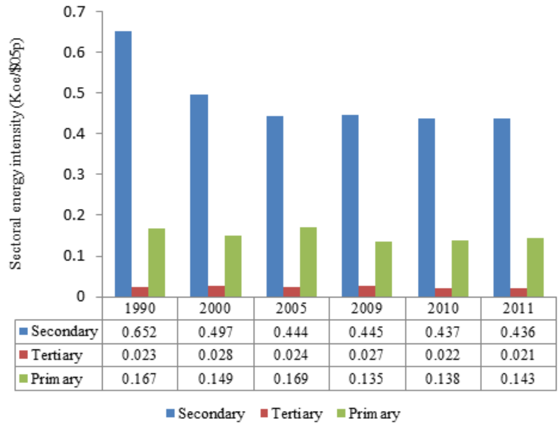

Fig. 2 Energy Intensity by Sectors [10]

South Africa has limited proven reserves of oil and natural gas and uses its large coal deposits to meet most of its energy needs, particularly in the electricity sector. Most of the oil consumed in the country is imported from Middle East and West African producers [9]. South Africa also has a well-developed synthetic fuels industry, producing gasoline and diesel fuels from the Secunda coal-to-liquids (CTL) and Mossel Bay gas-to-liquids (GTL) plants [9].

A. Economic Growth and Energy Consumption by Sectors

For the purpose of energy use, the South African economy is divided into the following sectors: Primary, Secondary, and Tertiary. The tertiary is the largest component of the GDP – contributing about 57 percent of the total GDP followed by the secondary and primary sectors which contribute 41 percent and 2 percent of the total GDP respectively in 2011 [10].

The primary sector, which is basically agriculture and mining sector, includes large modern commercial farms and small traditional subsistence farms. The primary sector consumed 2.7 percent of the total energy demand. The secondary sector (industry) accounts for about 45 percent, of total energy demand [11]. Coal is the main energy source for the following industries: iron and steel, chemicals (where it is used as feedstock), non-metallic minerals (where coal is mainly burnt in clamp kilns), pulp and paper, food, tobacco, and beverages [12]. Coal-based industries have low energy conversion efficiencies compared with oil, gas and hydro plants [13]. Although, the percentage of energy consumption is lower than that of the tertiary sector, its energy intensity is much higher than all other sectors combined (See Fig. 2). High energy intensities indicate high price of converting energy into gross domestic product (GDP).

The service (tertiary) sector includes transport, commerce and public service, and the residential sectors. The service sector consumes a total of 55.7 percent of the total energy demand. As economies develop, the service sector usually grows faster than other sectors. This is true for South Africa. Although, energy consumption is high, the energy intensity is relatively low and stable at 0.021 in 2011 compared to other sectors of the economy. Fig. 2 shows the energy intensity by sector.

III. Literature Review

Several empirical studies, using different approaches and data sets have been conducted on the causal relationship between energy consumption and economic growth in different countries. Their findings are mixed and inconclusive as to the directional of causality and the strength of the impact of energy consumption on economic growth [14]. The empirical literature is summarized into four testable hypothesis namely; growth hypothesis, conservation hypothesis, neutrality hypothesis and feedback hypotheses [6], [15]–[20].

A. Growth Hypothesis

The growth hypothesis asserts that energy consumption plays a vital role in economic growth both as a direct input in the production process or indirectly as a complement to labor and capital inputs. The growth hypothesis suggests that an increase in energy consumption causes an increase in real GDP (i.e. the economy is energy dependent). Under the growth hypothesis, energy conservation policies which reduce energy consumption may have a negative impact on real GDP [16], [21]. For example [16] in their study examined the relationship between energy consumption and economic growth for six Central American countries over the period 1980 to 2004 using a multivariate framework. Their findings revealed that there exists both short run and long run causality running from energy consumption to economic growth which supports the growth hypothesis.

Evidence of causality from energy consumption to economic growth was also found in the studies of [3], [22]-[25]. However, [26] suggested the "possibility that an increase in energy consumption may have a negative impact on real GDP". This may be as a result of excessive use of energy resources in relatively unproductive sectors of the economy, capacity constraints, or inefficiencies in energy production [21].

B. Conservation Hypothesis

The conservation hypothesis suggests that economic growth is the dynamic process which causes the consumption of energy resources. That is to say, economic growth drives energy consumption. The validity of the conservation hypothesis is proved if there is unidirectional causality from economic growth to energy consumption. In this situation, energy conservation policies which may prevent or reduce energy consumption will not have negative impact on economic growth. The conservation hypothesis is confirmed if an increase in real GDP causes an increase in energy consumption [16], [21]. For example, the studies of [5], [27], [17], revealed a unidirectional causality running from GDP to energy consumption. However, [26] argues that a growing economy that is inhibited by political influences, infrastructural inadequacy, or the mismanagement of resources may generate inefficiencies along with a reduction in the consumption of goods and services including energy.

C. Neutrality Hypothesis

The neutrality hypothesis considers energy consumption to be a small component of overall output and thus may have little or no impact on real GDP. As in the case of the conservation hypothesis, energy conservation policies would not have an adverse impact on real GDP. The neutrality hypothesis is supported by the absence of a causal relationship between energy consumption and real GDP. Empirical studies by [15] who used the Toda–Yamamoto procedure within a multivariate model framework by including measures of capital and employment and analyzed the causal relationship between renewable and non-renewable energy consumption and real GDP in the USA over the period 1949–2006. Results showed that there exists no causal relationship between renewable and non-renewable energy consumption and economic growth, indicating the presence of the neutrality hypothesis. Similarly, the neutrality hypothesis was valid for all countries examined in the study of [3] as mentioned earlier except Turkey.

D. Feedback (Bidirectional) Hypothesis

Under the feedback (bidirectional) hypothesis, energy consumption and real GDP are inter-related and may very well serve as complements to each other. The presence of bidirectional causality between energy consumption and real GDP supports the feedback hypothesis in an energy policy oriented toward improvements in energy consumption efficiency may not have an adverse impact on real GDP [16]. The studies of [22] in the case of Argentina, [28]-[33], [25], [6] provide evidence of bidirectional relationship between energy consumption and economic growth.

In the case of some emerging economies including South Africa, [8] examined the causal relationship between economic growth and coal, natural gas and oil consumption using the ARDL (autoregressive distributed lag bounds) testing approach from 1980 to 2011 in Brazil, Russia, India, China, Turkey and South Africa. Their findings reveal a strong bi-directional causal relationship between oil energy consumption and GDP for all countries. For coal consumption and GDP, there exists a strong bi-directional causal relationship for China and India. However, in the case of natural gas, there exists a bi-directional causal relationship only in the case of Brazil, Russia and Turkey [16].

IV. Methodology and Data

This study uses time series data of the growth rate of the gross value added (GVA) at basic prices for the three (primary, secondary and tertiary) sectors of the economy and growth rate of oil consumption, coal consumption and electricity consumption between 1980 and 2012 in South Africa. Growth rate of both the private and public employment and gross fixed capital formation were used as proxy for labor and capital respectively. Data on economic growth (GVA), labor and capital were obtained from [34], while that of energy (coal and oil) consumption were obtained from [35], [36]. In this paper, energy consumption is expressed in terms of Million Tons of Oil Equivalent (MTOE), while gross value added is measured in basic prices. The data on total electricity net consumption was sourced from the [37] and measured in Billion Kilowatt-hours.

For the analysis, this study adopts the widely used Johansen-Juselius cointegration test. A precondition for this test is that all variables must be integrated of order I(1). We therefore test for the stationarity of all the variables using the Augmented Dickey Fuller (ADF) and Phillips Perron (PP) test to identify the order of integration of each series. If the variables are found to be non-stationary then successive differencing has to be applied so that the series becomes stationary. According to [38], in general if a time series has to be differenced “d” times to make it stationary, that time series is said to be integrated in the order of “d”.

The ADF test takes into account cases where the error term, μ_t are correlated. That is to say, with this test the assumption is that the error term is independently distributed. According to [38], the ADF test involves estimating the following regression.

$$\Delta Y_t = \beta_1 + \beta_2 + \delta Y_{t-1} + \sum_{i=1}^{m} \alpha_i \Delta Y_{t-1} + \mu_t \quad (1)$$

where μ_t =pure white house noise error term.

The PP test will also be applied as an alternate test for unit root. The Phillips and Perron test use non-parametric statistical methods to take care of the serial correlation in the error terms without adding lagged difference term [39]. This corrects for any autocorrelation and heteroscedasticity in the errors and as such it gives robust estimates when the series has serial correlation and time-dependent heteroscedasticity [6].

The lag length is chosen based on the Akaike Information Criteria (AIC). Once the series are found to be integrated of the same order, we proceed to the second step. We employed Johansen-Juselius cointegration to test the presence of long run relationship among the variables. The Johansen-Juselius cointegration test provides two likelihood ratio (LR) tests based on the trace statistic and maximum eigenvalue statistic. They are formulated as;

$$\lambda_{trace}(r) = -T \sum_{i=r+1}^{m} In(1 - \hat{\lambda}_i) \quad (2)$$

and

$$\lambda_{\max}(r, r+) = -T\ln(1-\hat{\lambda}_i) \quad (3)$$

where r is the cointegrating vector under the null hypothesis and $\hat{\lambda}_i$ is the estimated value of ith eigenvalue of the eigenvalue. The null hypothesis that r cointegrating vector is rejected in favor of r+1 (for $\lambda_{\max}$) or more than r (for λ_{trace}) if the test statistic is greater than the critical value. H_0: r = 0, H_1: r > 1;

H_0: r ≤ 1, H_1: r > 1;

H_0: r ≤ 2, H_1: r > 2

where t=number of observation, r=0, 1, 2,……, m-1.

The Johansen cointegration test allows us to estimate cointegrating vectors between the non-stationary variables of the model, using the maximum likelihood technique which tests for the cointegrating rank. Although, the cointegration test confirms the presence of long run relationship, it does not point out its direction. This paper adopts the vector error correction model to investigate the direction of causality between the disaggregated energy consumption and sectoral growth in South Africa. The regression equation for the vector error correction model (VECM) is specified as:

$$\Delta Y_t = \beta_1 + \sum_{i=1}^{m} \beta_i \Delta Y_{t-i} + \sum_{i=1}^{n} \gamma_{i,t-i} \Delta ENY_{t-i} + \partial_1 ECM_{t-1} + \ell_t \quad (4)$$

$$\Delta ENY_t = \beta_1 + \sum_{i=1}^{m} \theta_i \Delta ENY_{t-i} + \sum_{i=1}^{n} \gamma_{i,t-i} \Delta Y_{t-i} + \partial_2 ECM_{t-1} + \ell_t \quad (5)$$

where Y is the proxy for sectoral growth rate, ENY is the proxy for growth rate of the disaggregated energy consumption growth. Residuals e_t are independent and normally distributed with zero mean and constant variance; ECM_{t-1} is the error correction term resulting from the long run equilibrium relationship; $\beta\gamma\theta\ \delta$ are parameters to be estimated while ∂ is the error correction coefficient. The error correction term coefficients indicate the speed of adjustment towards the long run equilibrium after a shock in the system. It shows how quickly variables adjust to the equilibrium and it must be significant with a negative sign. The significance of the error correction term also determines the long run causality running from all independent variables towards the dependent variable

V. Results and Discussion

The results obtained from the analysis of data and estimation of the VECM equation (4) and (5) on the causal relationship between disaggregated energy consumption and sectoral economic growth are presented in this section. Empirical procedure in time series regression analysis requires that we test for the stationarity of the variables and the order of integration. This study employed the Augmented Dickey Fuller (ADF) and Philip Peron (PP) to test stationarity of the variables. The tests were conducted with intercept only, intercept and trend and none. The study applied the Donaldo, Jenjinson and Sosvilla-Rivero 1990 [40] procedure to choose the appropriate model.

The ADF and PP tests with and without time trend indicate that the variables gross domestic product growth rate (GDPGR), energy consumption growth rate (ENYGR), labor growth rate (LABGR), capital investment growth rate (CAPGR), coal consumption rate (COLGR), oil consumption growth rate (OILGR), primary sector output growth rate (PRYGR), secondary sector output growth rate (SEYGR) and tertiary sector output growth rate (TEYGR) exhibit a unit root problem which means that they are not stationary at levels. This is because their estimated test statistic values are not more negative than their critical values at the 5 percent level of significance. For stationary of the series to be accomplished, the test for the series is carried out at first difference. The result of the test at first difference shows that all the series are stationary, that is, they are integrated of order one I(1) (Table IV: Appendix).

A. *Cointegration Test Result*

In order to test for the presence of long run relationship among the variables in the models the Johansen test of cointegration is applied and the result is presented in Table V (Appendix). The null hypothesis states that there is no cointegration, as opposed the alternative which states that cointegration is present. The decision rule is that we reject the null hypothesis that there is no cointegration if at least one of the maximum eigenvalue or trace statistics is greater than the critical value at the 5 percent level of significance.

For the primary sector energy consumption model, the Maximum eigenvalue statistic indicates that there exist two cointegrating vectors since we fail to reject the null hypothesis of "at most 2" cointegrating equations at 5 percent significance level. The trace statistic indicates that there exist three cointegrating equations. This indicates that there exists a long run equilibrium relationship among the variables (PRYGR, LABGR, CAPGR, COLGR, ELCGR and OILGR).

For the secondary sector energy consumption model, the cointegration test results as presented in Table V (Appendix) indicate that, the maximum eigenvalue statistic and the trace test statistics show that there is one and three cointegrating equation(s) respectively in the model. This means we reject the null hypothesis of no cointegration among the variables and conclude that there is a long run equilibrium relationship between the dependent variable secondary sector output (SEYGR) and the independent variables labor (LABGR), capital (CAPGR), coal consumption (COLGR), electricity consumption (ELCGR) and oil consumption (OILGR). The indication of at least one cointegrating equation in the model presupposes that a vector error correction model can be used to distinguish between the short run and long run effects of the variables in order to establish the effect of the energy consumption component on the secondary sector output.

In order to test for the presence of a long run relationship between tertiary output (TEYGR) and the various energy components (COLGR, ELCGR and OILGR) together with labor and capital, the Johansen test of cointegration is applied. The results are presented in Table V (Appendix). The maximum eigenvalue statistic indicates that there exists one cointegrating vector since we fail to reject the null hypothesis that there is at most 1 cointegrating equations at k percent significant level. The trace statistic on the other hand indicates that there exist two cointegrating equations. This indicates that there exists a long run equilibrium relationship among the variables. However, since the maximum eigenvalue and the trace statistic generated conflicting results, [41], [42] opined that the presence of more than one cointegrating vector presupposes that any combination of the vectors will also produce a cointegrating vector. In that case, the best alternative is to identify individual behavioral relationships through the restrictions of the cointegrating vectors. We therefore place a restriction on one of the cointegrating vector in the vector error correction model in order to examine the direction of causality.

B. Vector Error Correction Model Result and Diagnostic Testing

The VECM allows the long run behavior of the endogenous variables to converge to their long run equilibrium relationship while allowing a wide range of short run dynamics. A dummy variable was introduced to account for the shock (labor strike) in the primary sector comprising the agricultural and mining sectors and the electricity crisis of 2007 that affected the secondary sector. A dummy variable was also introduced but did not yield a desired result. It was, however removed. Error correction results and diagnostic testing for the primary, secondary and tertiary sectors are presented in Tables I, II and III respectively.

The result shown in Table I indicate that electricity consumption and oil consumption possess the correct sign and are highly significant at the 5 percent and 1 percent level significance respectively, with the speed of adjustment back to equilibrium of 26.5 percent and 41.8 percent in that order. This implies that in the advent of a shock in the system in the short run, electricity consumption and oil consumption will converge back to equilibrium by 26.5 percent and 41.8 percent of the previous year's deviation from equilibrium. The significance of the error correction term indicates that there exists a long run causal relationship running from (1) primary sector output, labor, capital, coal consumption and oil consumption to electricity consumption; (2) primary sector output, labor, capital, coal consumption and electricity consumption to oil consumption.

In summary, there exists a bidirectional long run causal relationship between electricity consumption and oil consumption, while there exist, unidirectional causal relationship from primary sector output to electricity consumption and also unidirectional causality running from the primary sector output to oil consumption. The unidirectional causality from the primary sector output growth rate to energy resource (electricity and oil consumption growth) implies that primary sector growth drives energy consumption and in that case energy conservation policy may not harm the economy. The diagnostic test presented in Table I indicates that there is no evidence of a diagnostic problem with the model.

TABLE I
SPEED OF ADJUSTMENT FOR THE PRIMARY SECTOR ENERGY CONSUMPTION MODEL

Variables	Coefficient	Standard error	t-statistic
PRYGR	-0.32946	0.19500	-1.68955
LABGR	-0.02859	0.15171	-0.18844
CAPGR	0.174949	0.26808	0.65259
COLGR	0.149386	0.17549	0.85126
ELCGR	-0.26545	0.13627	-1.94794**
OILGR	-0.41887	0.12115	-3.45751*

**, * means significant at the 1 and 5 percent levels of significance respectively

Test statistics	LM Version	F Version
A: serial correlation	CHSQ(10)=15.12929 [0.1274]	F(10, 11)= 1.119127 [0.4255]
B: Normality	JB= 0.086805* [0.957526]	Not applicable
C: Heteroscedasticity	CHSQ(14)=12.75870 [0.5456]	F(14, 15)= 0.792865 [0.6653]

Breusch-Godfrey Serial Correlation LM Test
*Jarque-Bera test Statistics
Heteroskedasticity Test: Breusch-Pagan-Godfrey
Note: Probability value in [ ]

TABLE II
SPEED OF ADJUSTMENT FOR THE SECONDARY SECTOR ENERGY CONSUMPTION MODEL

Variable	Coefficient	Standard error	t-statistic
SEYGR	-0.15387	0.16375	-0.93969
LABGR	0.066332	0.16486	0.40235
CAPGR	0.513203	0.27412	1.87216
COLGR	0.184091	0.18883	0.97493
ELCGR	-0.31566	0.14320	-2.20435**
OILGR	-0.53708	0.12066	-4.45099*

**, * means significant at the 5 and 1 percent level of significance respectively

Test statistics	LM Version	F Version
A: serial correlation	CHSQ(2)= 0.950433 [0.6218]	F(2, 19)= 0.310818 [0.7365]
B: Normality	JB= 0.518473* [0.771640]	Not applicable
C: Heteroscedasticity	CHSQ(14)=11.81890 [0.6208]	F(14, 15)= 0.696499 [0.7477]

Breusch-Godfrey Serial Correlation LM Test
*Jarque-Bera test Statistics
Heteroskedasticity Test: Breusch-Pagan-Godfrey
Note: Probability value in [ ]

From the results presented in Table II, the error correction term of electricity consumption and oil consumption models possess the correct sign and is statistically significant at the 5 and 1 percent significance level, with the speed of adjustment back to equilibrium of 31.6 and 53.7 percent respectively. In the case of any misalignment in the equilibrium level of electricity consumption and oil consumption, all the explanatory variables in the VECM will act together to re-establish long run equilibrium. The coefficients suggest that any deviation in the electricity consumption model and the oil consumption model will be corrected by about 31.6 and 53.7 percent respectively in the following year. Thus, it will take approximately 31.6 and 0.54 years for the deviation in the electricity consumption and oil consumption to completely disappear. The significance of the t-statistic imply that there is a long run causality running from the secondary sector output, labor, capital, coal consumption and oil consumption to electricity consumption as well as from the secondary sector output, labor, capital, coal consumption and electricity consumption to oil consumption. The results also suggest that as the industrial sector expands, there will also be an expansion in the demand for electricity and oil resources in the long run. Therefore policy makers should take adequate steps to increase electricity generating and oil production capacities in the long run in order to meet the future increase in demand.

TABLE III
SPEED OF ADJUSTMENT FOR THE TERTIARY SECTOR ENERGY CONSUMPTION MODEL

Variable	Coefficient	Standard error	t-statistic
TEYGR	-0.20437	0.11490	-1.77874***
LABGR	0.034012	0.28036	0.12132
CAPGR	0.635918	0.47761	1.33145
COLGR	0.172949	0.31390	0.55097
ELCGR	-0.43486	0.25625	-1.69699
OILGR	-1.02407	0.17633	-5.80768*

***, **, * means significant at the 10, 5 and 1 percent levels of significance respectively

Test statistics	LM Version	F Version
A: serial correlation	CHSQ(2)=1.939528 [0.3792]	F(2, 19)= 0.656636 [0.5300]
B: Normality	JB= 4.639782* [0.098284]	Not applicable
C: Heteroscedasticity	CHSQ(16)=12.12312 [0.5964]	F(14, 15)= 0.726584 [0.7221]

Breusch-Godfrey Serial Correlation LM Test
*Jarque-Bera test Statistics
Heteroskedasticity Test: Breusch-Pagan-Godfrey
Note: Probability value in [ ]

From the results presented in Table III the error correction term of tertiary sector output and oil consumption possess the correct sign, which is negative and statistically significant at the 10 percent and 1 percent level of significance respectively. This implies that there is long run bidirectional causality between tertiary sector output and oil consumption. The long run bidirectional causality indicates that they are compliments and that oil conservation policy may be implemented without necessarily affecting output in the tertiary sector. The result further indicates that there is a long run unidirectional causality from coal consumption, electricity consumption to tertiary sector output. This means growth in the tertiary sector drives energy consumption, thereby supporting the growth hypothesis with regards to coal consumption and electricity consumption. All diagnostic tests were passed. This implies that there are no diagnostic problems in the model.

VI. Summary and Policy Implications

The study investigated the impact of the energy components (coal, oil, and electricity) on the primary, secondary and tertiary sectors of the economy between 1980 and 2012. The overall object of this study was to examine and discuss the implication of disaggregated energy consumption (COLGR, ELCGR, and OILGR) on the primary (PRYGR), secondary (SEYGR) and tertiary (TEYGR) sectors of the South African economy. Empirical findings revealed that there exists long run bidirectional causality between tertiary sector output to oil consumption and unidirectional causality from electricity consumption to tertiary sector output, while In the case of the primary and secondary sectors, there exist long run unidirectional causal relationship running from economic output to oil consumption, as well as electricity consumption.

It is established that South Africa is an energy dependent economy and that energy (especially electricity and oil) is a limiting factor of growth. This implies that implementation of energy conservation policies may hamper economic growth. There is therefore need to increase investment, especially in the electricity sector as well as to take strategic steps to increase oil production. In the long run, there should be increased generating capacity to meet future demands. There will also be a need to explore more renewable sources in order to meet the growing energy demand without compromising growth and environmental sustainability. Apart from increasing the electricity generating capacity to meet future demands, policy makers should also pursue energy efficiency policies both at the aggregated and disaggregated level. Also, improving energy efficiency will have a significant impact on the provision of energy to meet sustainable development goals. South Africa needs to pursue energy efficiency policies more diligently in the long term, in the same manner as renewable energy policies, as they both have similar benefits in terms of energy security and climate change mitigation.

APPENDIX

TABLE V
COINTEGRATION TEST RESULTS

Hypothesized No. of CE(s)	Max-Eigen statistic	5% critical values	Trace test statistic	5% critical values
Primary sector				
None	51.11635*	46.23142	169.1751*	125.6154
At most 1	47.03417*	40.07757	118.0587*	95.75366
At most 2	27.68750	33.87687	71.02457*	69.81889
At most 3	18.38765	27.58434	43.33707	47.85613
At most 4	10.51941	21.13162	24.94942	29.79707
At most 5	8.230333	14.26460	14.43000	15.49471
Secondary sector				
None	63.05404*	46.23142	167.1280*	125.6154
At most 1	31.77262	40.07757	104.0739*	95.75366
At most 2	25.91144	33.87687	72.30132*	69.81889
At most 3	21.67468	27.58434	46.38988	47.85613
At most 4	12.51876	21.13162	24.71520	29.79707
At most 5	10.07689	14.26460	12.19644	15.49471
Tertiary sector				
None	64.64034*	46.23142	161.5872*	125.6154
At most 1	35.43867	40.07757	96.94683*	95.75366
At most 2	19.05414	33.87687	61.50816	69.81889
At most 3	17.45915	27.58434	42.45402	47.85613
At most 4	12.94247	21.13162	24.99488	29.79707
At most 5	9.091451	14.26460	12.05241	15.49471

* denotes rejection of null hypothesis at the 5% level of significance.

TABLE IV
STATIONARITY TEST RESULT

	Augmented Dickey Fuller		Phillip Perron	
Variables	T statistic	Critical value (5%)	T statistic	Critical value 5% Bandwidth []
GDPGR	-1.384535	-3.562882 (1)1	-0.692660	-3.557759 [1]1
D(GDPGR)	-4.548317*	-3.562882(0)1	-4.505098*	-3.562882 [4]1
ENYGR	-1.981241	-2.957110 (0)2	-3.211604	-3.557759 [1]1
D(ENYGR)	-5.229000*	-2.960411(0)2	-5.226070*	-3.562882 [3]1
CAPGR	-0.849517	-3.562882 (1)1	-0.366002	-3.557759 [4]1
D(CAPGR)	-3.844668*	-3.562882 (0)1	-3.626088*	-3.562882 [11]1
LABGR	0.790603	-1.952066 (1)3	1.503567	-1.951687 [3]3
D(LABGR)	-2.561431*	-1.952066 (0)3	-2.537981*	-1.952066 [2]3
COLGR	-3.155497	-3.562882 (1)1	-3.260572	-3.557759 [1]1
D(COLGR)	-4.776846*	-3.562882 (0)1	-4.812255*	-3.562882 [5]1
ELCGR	-2.487314	-3.557759 (0)1	-2.537565	-3.557759 [1]1
D(ELCGR)	-5.065980*	-3.568379 (1)1	-5.767457*	-3.562882 [3]1
NAGGR	-2.053214	-3.562882 (1)1	-1.737175	-3.557759 [3]1
D(NAGGR)	-4.233449*	-3.562882 (0)1	-4.065593*	-3.562882 [7]1
OILGR	0.055936	-2.971853 (4)2	-0.898142	-2.957110 [31]2
D(OILGR)	-4.524109*	-2.971853 (3)2	-11.47784*	-2.960411 [30]2
PRYGR	-2.904936	-2.957110 (0)2	-2.808226	-2.957110 [3]2
D(PRYGR)	-7.194858*	-2.963972 (1)2	-11.52286*	-2.960411 [8]2
SEYGR	-1.179721	-3.557759 (0)1	-1.067382	-3.557759 [4]1
SEYGR	-5.370753*	-3.562882 (0)1	-5.665098*	-3.562882 [6]1
TEYGR	-0.465147	-3.568379 (2)1	0.465147	-3.568379 [2]1
D(TEYGR)	-6.083840*	-3.574244 (1)1	-6.083840*	-3.574244 [1]1

'*' means significant at 5 percent level of significance; for the restriction, 1, 2, 3 stands for constant and linear trend, constant & none respectively; lag length and bandwidth in parenthesis '()' and [] respectively.

REFERENCES

[1] C.-C. Lee, "The causality relationship between energy consumption and GDP in G-11 countries revisited," Energy Policy, vol. 34, no. 9, pp. 1086–1093, Jun. 2006.
[2] N. D. Uri, "A reconsideration of the effect of energy scarcity on economic growth," Energy, vol. 20, no. 1, pp. 1–12, 1995.
[3] E. Yıldırım, D. Sukruoglu, and A. Aslan, "Energy consumption and economic growth in the next 11 Countries: The bootstrapped autoregressive metric causality approach," Energy Econ., vol. 44, pp. 14–21, 2014.
[4] D. I. Stern, "A multivariate cointegration analysis of the role of energy in the US economy," Energy Econ., vol. 22, pp. 267–83, 2000.
[5] M. J. Herrerias, R. Joyeux, and E. Girardin, "Short- and long-run causality between energy consumption and economic growth: Evidence across regions in China," Appl. Energy, vol. 112, pp. 1483–1492, 2013.
[6] N. M. Odhiambo, "Electricity consumption and economic growth in South Africa: A trivariate causality test," Energy Econ., vol. 31, no. 5, pp. 635–640, Sep. 2009.
[7] E. Ziramba, "Disaggregate energy consumption and industrial production in South Africa," Energy Policy, vol. 37, no. 6, pp. 2214–2220, Jun. 2009.
[8] M. E. Bildirici and T. Bakirtas, "The relationship among oil, natural gas and coal consumption and economic growth in BRICTS (Brazil, Russian, India, China, Turkey and South Africa) countries," Energy, vol. 65, pp. 134–144, Feb. 2014.
[9] "Country analysis briefs: South Africa," Energy Information Agency, 2014. (Online). Available: http://www.eia.gov/countries/cab.cfm/fips=sf.
[10] "World development Indicator 2014," World Bank, 2014. .
[11] "Digest of South African energy statistics 2006," Department of Minerals and Energy, 2006. .
[12] "South African energy synopsis 2010," Department of Energy, 2010. (Online). Available: www.doe.gov.za.
[13] A. Eberhard and C. Van Horen, Poverty and Power. London: London Pluto Press, 1995.
[14] N. S. Ouedraogo, "Energy consumption and economic growth: Evidence from the economic community of West African States (ECOWAS)," Energy Econ., vol. 36, pp. 637–647, Mar. 2013.
[15] N. Bowden and J. E. Payne, "The causal relationship between U.S. energy consumption and real output: A disaggregated analysis," J. Policy Model., vol. 31, no. 2, pp. 180–188, Mar. 2009.
[16] N. Apergis and J. E. Payne, "Energy consumption and economic growth in Central America: Evidence from a panel cointegration and error correction model," Energy Econ., vol. 31, no. 2, pp. 211–216, 2009.
[17] L. Jinke, S. Hualing, and G. Dianming, "Causality relationship between coal consumption and GDP: difference of major OECD and non-OECD countries," Appl. Energy, vol. 85, no. 6, pp. 421–429, Jun. 2008.
[18] S. Z. Tsani, "Energy consumption and economic growth: A causality analysis for Greece," Energy Econ., vol. 32, no. 3, pp. 582–590, May 2010.
[19] N. M. Odhiambo, "Energy consumption and economic growth nexus in Tanzania: An ARDL bounds testing approach," Energy Policy, vol. 37, no. 2, pp. 617–622, 2009.
[20] L. Dagher and T. Yacoubian, "The Causal Relationship between Energy Consumption and Economic Growth in Lebanon," Energy Policy, vol. 50, no. 2010, pp. 795–801, 2012.
[21] N. Apergis and J. E. Payne, "Energy consumption and economic growth: Evidence from the Commonwealth of Independent States," Energy Econ., vol. 31, no. 5, pp. 641–647, 2009.
[22] U. Soytas and R. Sari, "Energy consumption and GDP: Causality relationship in G-7 countries and emerging markets," Energy Econ., vol. 25, no. 1, pp. 33–37, Jan. 2003.
[23] A. E. Akinlo, "Electricity consumption and economic growth in Nigeria: Evidence from cointegration and co-feature analysis," J. Policy Model., vol. 31, no. 5, pp. 681–693, 2009.
[24] J. Yuan, C. Zhao, S. Yu, and Z. Hu, "Electricity consumption and economic growth in China: cointegration and co-feature analysis," Energy Econ., vol. 29, no. 6, pp. 1179–1191, Nov. 2007.
[25] S. Tsani, "Natural resources, governance and institutional quality: The role of resource funds," Resour. Policy, 2012.
[26] J. Squalli, "Electricity consumption and economic growth: Bounds and causality analyses of OPEC members," Energy Econ., vol. 29, no. 6, pp. 1192–1205, Nov. 2007.
[27] S. M. Onuonga, "The relationship between commercial energy consumption and gross domestic income in Kenya," The Journal of Developing Areas, vol. 46, no. 1. pp. 305–314, 2012.

[28] S. Nasreen and S. Anwar, "Causal relationship between trade openness, economic growth and energy consumption: A panel data analysis of Asian countries," Energy Policy, vol. 69, pp. 82–91, Jun. 2014.
[29] M. Shahiduzzaman and K. Alam, "Cointegration and causal relationships between energy consumption and output: Assessing the evidence from Australia," Energy Econ., vol. 34, no. 6, pp. 2182–2188, Nov. 2012.
[30] A. Belke, F. Dobnik, and C. Dreger, "Energy consumption and economic growth: New insights into the cointegration relationship," Energy Econ., vol. 33, no. 5, pp. 782–789, 2011.
[31] G. Zou and K. W. Chau, "Short- and long-run effects between oil consumption and economic growth in China," Dec. 2006.
[32] W. Oh and K. Lee, "Causal relationship between energy consumption and GDP revisited : The case of Korea 1970 – 1999," vol. 26, pp. 51–59, 2004.
[33] G. Erdal, H. Erdal, and K. Esengün, "The causality between energy consumption and economic growth in Turkey," Energy Policy, vol. 36, no. 10, pp. 3838–3842, Oct. 2008.
[34] S. A. R. Bank, "Online database," 2014. (Online). Available: www.resbank.co.za.
[35] "BP Statistical review of world energy," BP Statistics, 2013. (Online). Available: <http://www.bp.com/statisticalreview>.
[36] "BP Statistical Review of World Energy," BP Statistics, 2014. (Online). Available: www.bp.com/statisticalreview.
[37] "World energy outlook 2014 factsheet energy in Sub-Saharan Africa today," International Energy Agency, 2014. (Online). Available: www.worldenergyoutlook.org.
[38] D. Gujarati and D. Porter, Basic econometrics, 5th ed. Palgrave Macmillan, 2009.
[39] D. Gujarati, Basic econometrics, Fourth. The McGraw-Hill Companies, 2004.
[40] A. Dimitrios and G. H. Stephen, Applied econometrics: A modern approach, Revised Ed. New York: Palgrave Macmillan, 2007.
[41] W. Enders, Applied econometric time series, 2nd ed. New York: Wiley & Sons Inc, 2004.
[42] B. Chris, Introductory econometrics for finance, 3rd Editio. United Kingdom: Cambridge University Press, 2014.