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Article

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Consumption and Supply of Electricity on Economic Growth in South Africa: An Econometric Approach

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ABSTRACT

This study investigates the relationship between electricity consumption and electricity supply on economic growth in South Africa for the period spanning from 1971 to 2014. The importance of this study is to reveal the short run and long run impact of electricity consumption and electricity supply on economic growth in South Africa. The study borrowed annual time series data from the World Bank online secondary source for the period from 1971 to 2014. Empirical results revealed a positive statistically significant short run relationship and a negative statistically insignificant long run relationship between electricity consumption and economic growth. The results further reveal that renewable electricity has a short run negative statistically significant and positive statistically significant long-run relationship with economic growth in South Africa. Based on empirical results, it can therefore be recommended that the policymakers should implement policies that promotes renewable electricity generation and evaluate policies on electricity consumption so that it can significantly boosts economic growth in the long run.

Keywords: Electricity Consumption, Electricity Supply, Economic Growth, Autoregressive Distributed Lag, South Africa
JEL Classifications: C1, Q41, Q43

1. INTRODUCTION

The availability of electricity serves as an important component in the country's survival in the short run and long run, as it plays a most indispensable role in both production and consumption of goods and services within an economy. Electricity has contributed immensely to technological and scientific advancement that have enhanced the economic development across the countries. The households consumption of electricity in South Africa has been increasing due to the increasing population, thus, this led to a shortage of electricity. Joffe (2012) emphasised that South Africa's power system remains constrained and will take some several years, until the new power stations of Eskom, such as Medupi and Kusile, deliver the capacity needed to ease the shortage of supply. The present study explored the literature of the related studies of consumption and electricity supply. However, many studies focused either on consumption of electricity on economic growth or supply of electricity on economic growth. The following studies are the studies obtained positive relationship between electricity consumption and economic growth such as Mohanty and Chaturvedi (2015), Niu et al. (2013), Ouédraogo (2010), Athukorala and Wilson (2010), Debnath et al. (2015), Bekhet and bt Othman (2011), and with electricity supply Lionel (2013).

To the best of our knowledge, there is no study in South Africa investigated the consumption and electricity supply in South Africa on households using ARDL bounds test approach. This study has been done to close the gap and also to open a platform for continuous research, as the present study might not have access to explore some of the variables in the energy sector. The paper is structured as follows: Section 2 focused on the review of the empirical literature. Section 3 present research method. Section 4 presents empirical results of the study. Section 5 presents a conclusion of the study.

1.2. Overview of the Study

The consumption of electricity has been increasing significantly overwhelming supply of electricity, which led to high levels of loadshedding in South Africa. In the schematic above, it is clearly displayed that from 2014 to 2017 the times of loadshedding were very, the only time where the loadshedding was normally experienced is during December as shown in Figure 1 that the power producers would need at least 203 GWh to overcome the high demand of electricity. Looking at period from 2018 to 2020, there are high levels of loadshedding as from January until December, this is due to an increase in the number of households in South Africa leading to high demand of electricity. Therefore, in this case the consumption of electricity in South Africa is greater than the supply of electricity.

In the Figure 2, it is demonstrated that in 2020 after March the loadshedding halted due to COVID-19 shutdown until July. The consumption of electricity in South Africa is much greater than the supply of electricity. This simply means that, in the case of South Africa, to avoid loadshedding all the economic activities must be closed, since it was proven by times of lockdown where the loadshedding absolutely stopped. This where the study of Joffe (2012) takes place to say that the new power stations of Eskom must deliver the capacity needed to reduce the shortage of electricity in South Africa.

2. EMPIRICAL LITERATURE

There is an extensive literature investigating the relationship between consumption of electricity and economic growth or electricity supply and economic growth. However, the purpose of this study investigates the relationship between consumption and electricity supply on economic growth in South Africa. This section is into two parts such as studies found positive relationships, and studies found an inverse relationship.

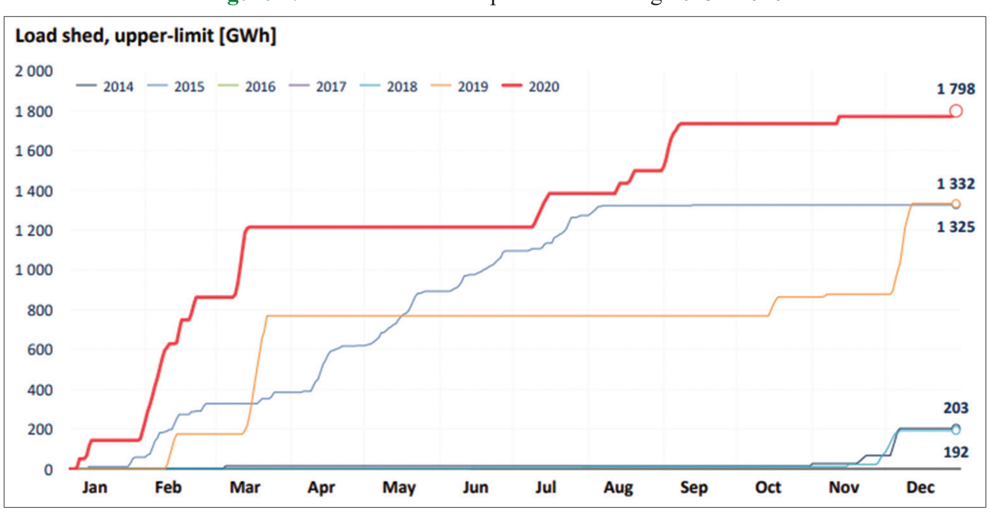
2.1. Studies Found Positive Relationship

Athukorala and Wilson (2010) investigate the short run dynamics and long run equilibrium relationship between the residential electricity demand and the factors influencing demand, like capita income, price of electricity, price of kerosene oil and price of liquefied petroleum gas using an onion data for Sri Lanka for the period of 1960-2007. The main findings of the paper was that increasing the price of electricity is not the most effective tool to reduce electricity consumption. Jamil and Ahmad (2010) investigated the relationship between electricity consumption, electricity prices and economic growth in Pakistan. The study employed annual time series data spanning for the period from 1960 to 2008. The study employed a Vector Error Correction Model (VECM) and Granger causality test to analyse the relationship between the variables in Pakistan. Empirical results revealed short run positive relationship between electricity consumption and economic growth in Pakistan. Granger causality results revealed unidirectional causal relationship from economic growth to electricity consumption that indicates economic growth stimulates electricity consumption in the long run. The researchers recommend that it is essential for Pakistan policymakers to plan and increase infrastructure development to meet increasing electricity demand. The researchers also recommend that government should adopt policies to sustain electricity supply.

Ouédraogo (2010) examined the direction of causality between electricity consumption and economic growth in Burkina Faso for the period of 1968 and 2003. The bounce test yields evidence of cointegration between electricity consumption GDP and capital formation when electricity consumption and GDP are used as dependent variables. The start argued that electricity is a significant factor in socio economic development in Burkina Faso, therefore energy policies must be implemented to ensure that electricity generates few potential negative impacts.

Bekhet and bt Othman (2011) investigated the relationship between electricity consumption, consumer price index, gross domestic product, and foreign indirect investment for period of 1971 and 2009. The vector error correction model was employed to estimate the causal relationship between electricity consumption with respective independent variables. The results demonstrated that electricity consumption was cointegrated with all their respective

Figure 1: Cumulative build up of loadshedding 2015 - 2020



Source: Joanne CALITZ (2021)

independent variables. The results further showed that there was a long run causality from electricity consumption to FDI, GDP growth and inflation was found to be significant.

Niu et al. (2013) analyzed the causality between electricity consumption and human development and assesses the changing trend of electricity consumption. they have started employed panel data from 1990 to 2009 for 50 countries divided into four groups according to the income. For human development indicator, per capita GDP, consumption expenditure, urbanization rate, life expectancy at birth and the adult literacy rate was selected. The result from the study demonstrated long run bidirectional causality existing between electricity consumption and five indicators. The study further suggested, in order to enhance human development, the electricity should be incorporated into the basic public services construction to improve the availability of electricity for low-income residents.

Lionel (2013) investigated the relationship between electricity supply and economic development in Nigeria using an annual time series data from 1970 to 2009. The paper employed error correction model for empirical analysis of the study. The results showed that per capita GDP, lagged electricity supply, Technology, cut it down at the significant variables that influence economic development in Nigeria. Electricity supply has an influence in economic development in Nigeria, but its impact is very low.

Bangladesh one of the largest populous countries in the world is being overwhelmed by an access demand of energy from the households, hence, Debnath et al. (2015) investigated the bottom up approach towards modelling the aggregate energy demand of right households of Bangladesh from 2010 to 2015. The energy demand pathway model demonstrated a significant rise in energy demand. Mohanty and Chaturvedi (2015) examine the weather electricity energy consumption on economic growth in Indian using the annual data spanning 1970-1971 to 2011-2012. Using granger causality test and Engle-Granger technique, their study suggested that electricity energy consumption has a positive relationship on economic growth in the short run and long run.

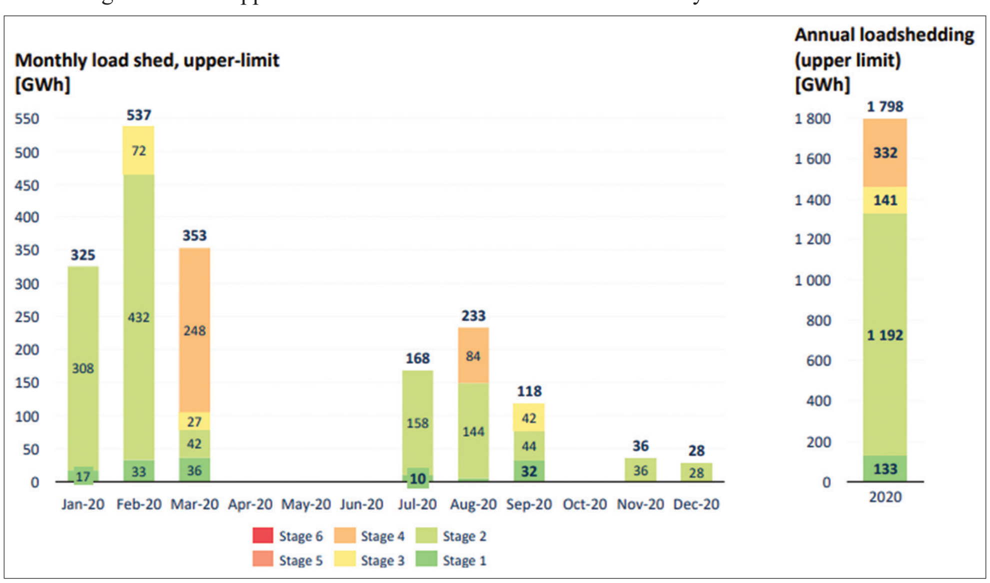
Hussain et al. (2016) forecasted electricity consumption in Pakistan. The study borrowed available annual time series data spanning for the period from 1980 to 2011. The study employed Holt-Winter and Autoregressive Integrated Moving Average (ARIMA) models to forecast electricity consumption in Pakistan. The empirical results revealed that electricity demand is higher in the household sector than in other sectors and that electricity generation would be lesser than the increase in electricity generation. The researchers recommend that policymakers should focus on short- and long-term projects such as renewable sources of electricity to balance the supply-demand gap in Pakistan.

da Silva et al. (2016) investigated electricity supply security and the future role of renewable energy sources in Brazil. The researchers found that hydroelectricity generation is the backbone of electricity supply in Brazil. The recent drought exposed the exposed vulnerability of electricity supply and drew significant immediate attention to address power outages. The researchers highlight that Brazil faces considerable increases in electricity consumption and policy makers should focus on renewable energy sources to balance energy supply and reduce dependence on hydroelectric power.

Osman et al. (2016) conducted a study on electricity consumption and economic growth in the GCC countries. The study borrowed available annual panel data spanning from 1975 to 2012. The study employed panel estimation techniques to analyse the relationship between the variables. Empirical results revealed positive results between the variables both in the short and long run period. The researchers recommend that if these countries adopt or implement policies that conserve electricity, this will have negative impact on economic growth of these countries.

Salahuddin and Alam (2016) conducted a study on information and communication technology, electricity consumption and economic

Figure 2: Loadshedding to March stopped after COVID-19 lockdown but returned by winter and remained for most of H2-2020



Source: Joanne CALITZ (2021)

growth in OECD countries. The study borrowed available annual panel data spanning for the period from 1985 to 2012. The study employed panel estimation techniques to analyse the relationship between the variables. Empirical results revealed that electricity consumption boost economic growth. Based on empirical results, the researchers recommend the adaption of technologies that promotes efficiency electricity consumption to reduce hazards arising from electricity consumption.

Zhang et al. (2017) investigated electricity consumption and economic growth in China. The study utilises available literature spanning from 1978 to 2016 that focuses on electricity generation and economic growth. The study reveals that vector error correction model (VECM) and vector autoregressive (VAR) model are the most employed models in the analysis. The study revealed that there is interaction between electricity consumption and economic growth. The researchers stresses that due to employment of different models, the results are not the same. The researchers recommend that China should increase the renewable sources of electricity to balance the strain on electricity supply and maintain environmentally friendly status.

Ouedraogo (2017) modelled sustainable long-term electricity supply-demand in Africa. The study employed the system-based approach developed by Schwartz in the context of Long-range alternative planning. The results revealed that despite the increase in the electricity generation, the demand for electricity will still be prevailing by 2030 and 2040 implying the insufficient in electricity supply. The researchers suggest that energy efficiency policies should be implemented to reduce the high energy consumption levels in Africa.

Shahbaz et al. (2017) conducted a study on the dynamics of electricity consumption, oil price and economic growth on a panel global perspective. The study borrowed available annual panel data for 157 countries spanning from 1960 to 2014. The study employed panel estimation techniques to analyse the relationship between the variables. Empirical results revealed a short run positive relationship of electricity consumption on economic growth. The researchers reveals that more vigorous policies on electricity to be implemented to attain sustainable long run economic growth. The study recommends electricity conversion policies to trigger economic growth.

Belaid and Youssef (2017) conducted a study on environmental degradation, renewable and non-renewable electricity consumption on economic growth in Algeria. The study borrowed annual time series data spanning from 1980 to 2012. The study employed an autoregressive distributed lad model and Granger causality test to analyse the relationship between the variables in Algeria. Empirical results revealed a unidirectional long run causality between the variables. The study recommends that investment in renewable electricity will boosts economic growth that will help fight unemployment in Algeria.

Kahouli (2018) investigated the causal relationship between electricity consumption, CO2 emissions, research and development stocks and economic growth of Mediterranean countries. The study borrowed annual panel data spanning for the period from 1990 to 2016. The study employed panel estimation techniques to analyse the relationship between the variables. The empirical results revealed that electricity consumption boosts economic growth in the Mediterranean countries. The researchers recommend that policymakers should implement policies of electricity that are environmentally friendly.

Khobai (2018) investigated causal linkages between renewable electricity generation and economic growth in South Africa. The study utilised quarterly time series data spanning from first quarter in 1997 to fourth quarter in 2012. The study employed a vector error correction model and granger causality tests to analyse the relationship between the variables. The empirical results reviewed a unidirectional causality running from electricity generation to economic growth and that electricity generation from renewable energy source enhances economic growth. The researchers recommend that the South African government should make appropriate effort to select energy policies that do not negatively affect economic growth.

Dey and Tareque (2019) investigates the electricity consumption and gross domestic product nexus in Bangladesh. The study borrowed the available time series data spanning from 1971 to 2014. The study employs an autoregressive distributed lag model to analyse the relationship between Bangladesh's electricity consumption and economic growth. Empirical results revealed a positive relationship between electricity consumption and economic growth both in the short and long run period. The researchers recommend that electricity generation and conservation policy will be effective in Bangladesh.

Bekun et al. (2019) investigated the relationship between energy consumption, carbon emissions and economic growth in South Africa. The study borrowed available annual time series data spanning for the period from 1960 to 2016. The study employed Granger causality test to analyse the relationship between the variables in South Africa. The results revealed a positive relationship between electricity consumption and economic growth in South Africa. The researchers recommend that the electricity conservation policies harm economic growth.

2.2. Studies that Found an Inverse Relationship

Ha and Ngoc (2021) revisits the relationship between energy consumption and economic growth in Vietnam. The study borrowed available annual time series data spanning for the period from 1971 to 2017. The study employs an asymmetric autoregressive distributed lag model to analyse the relationship between the variables. The empirical results revealed that the negative impacts are greater than the positive impacts both in the short and long run of electricity consumption on economic growth in Vietnam. The researchers recommend that the government should encourage enterprises and people to use intelligent equipment and low electricity consumption machines while adopting renewable energy sources as an alternative.

Shahbaz (2015) examined the impact of electricity shortage on sectoral GDP such as agriculture, industrial and service sectors in the case of Pakistan for the period of 1991 to 2013. the ordinary least squared (OLS) Was used for empirical analysis of the study. The results from the study demonstrated that electricity shortage is inversely linked with it agricultural sector output, and the result further showed that industrial the sector output is inversely affected by electricity shortage.

3. METHODOLOGY

The study examines the consumption and supply of electricity on economic growth in South Africa. The present study adopts an Autoregressive Distributed Lag (ARDL) model to estimate the long run behaviour of consumption and supply of electricity on economic growth in South Africa. However, the study further employs Error Correction Model to explore the short run relationship between consumption and supply of electricity on economic growth in South Africa. The variables under the study are exposed on unit root test using Augmented Dickey-Fuller (ADF), Philips-Perron (PP), and Kwiatkowski-Philips-Schmidt-Shin (KPSS) unit root test. Furthermore, the study recruits ARDL bounds test to investigate the presence of cointegration across the variables. The diagnostic tests are performed to check for the stability, serial correlation, heteroskedasticity, and histogram normality (Jarque-Bera).

3.1. Empirical Model Estimation

Empirical model estimation: The model used in this study was adopted from the studies carried by Belaid and Youssef (2017) and Dey and Tareque (2019). The econometric model specification is represented as given in equation 1 below.

$$LGDP_t = \beta_0 + \beta_1 LELC_t + \beta_2 LEGNR_t + \beta_3 LEGR_t + \varepsilon_t \quad (1)$$

Where:
L – represents a logged variable
LGDP – Gross domestic product per capita in annual percentages
LELC – Electric power consumption (kWh per capita)
LEGNR – Electricity generation from non-renewable sources (oil, coal, and gas)
LEGR – Renewable electricity output (% of total electricity output)

Estimation of long run relationship: Once cointegration has been established among the variables, the ARDL model that can be specified as given below for long run estimations:

$$LGDP_t = \beta_{01} + \sum_{i=1}^{p} k_{11} LGDP_{t-i} + \sum_{i=0}^{q} k_{21} LELC_{t-i} + \sum_{i=0}^{q} k_{31} LEGNR_{t-i} + \sum_{i=0}^{q} k_{41} LEGR_{t-i} + \varepsilon_t \quad (2)$$

$$LELC_t = \beta_{02} + \sum_{i=1}^{p} k_{12} LELC_{t-i} + \sum_{i=0}^{q} k_{22} LGDP_{t-i} + \sum_{i=0}^{q} k_{32} LEGNR_{t-i} + \sum_{i=0}^{q} k_{42} LEGR_{t-i} + \varepsilon_t \quad (3)$$

$$LEGNR_t = \beta_{03} + \sum_{i=1}^{p} k_{13} LEGNR_{t-i} + \sum_{i=0}^{q} k_{23} LELC_{t-i} + \sum_{i=0}^{q} k_{33} LGDP_{t-i} + \sum_{i=0}^{q} k_{43} LEGR_{t-i} + \varepsilon_t \quad (4)$$

$$LEGR_t = \beta_{04} + \sum_{i=1}^{p} k_{14} LEGR_{t-i} + \sum_{i=0}^{q} k_{24} LEGNR_{t-i} + \sum_{i=0}^{q} k_{34} LELC_{t-i} + \sum_{i=0}^{q} k_{44} LGDP_{t-i} + \varepsilon_t \quad (5)$$

3.2. Short Run Relationships

The short run dynamic error correction model can therefore be derived from an ARDL model through a simple linear transformation. The dynamic short run with long run equilibrium is therefore incorporated by an unrestricted ECM ECT_{t-1} with that is an error correction term that should be negative and statistically significant. Δ represents a differenced variable.

$$\Delta LGDP_t = \beta_{01} + \sum_{i=1}^{p} \alpha_{1i} \Delta LGDP_{t-i} + \sum_{i=0}^{q} \alpha_{2i} \Delta LELC_{t-i} + \sum_{i=0}^{q} \alpha_{3i} \Delta LEGNR_{t-i} + \sum_{i=0}^{q} \alpha_{4i} \Delta LEGR_{t-i} + \lambda ECT_{t-1} \varepsilon_t \quad (6)$$

$$\Delta LELC_t = \beta_{02} + \sum_{i=1}^{p} \alpha_{1i} \Delta LELC_{t-i} + \sum_{i=0}^{q} \alpha_{2i} \Delta LGDP_{t-i} + \sum_{i=0}^{q} \alpha_{3i} \Delta LEGNR_{t-i} + \sum_{i=0}^{q} \alpha_{4i} \Delta LEGR_{t-i} + \lambda ECT_{t-1} \varepsilon_t \quad (7)$$

$$\Delta LEGNR_t = \beta_{03} + \sum_{i=1}^{p} \alpha_{1i} \Delta LEGNR_{t-i} + \sum_{i=0}^{q} \alpha_{2i} \Delta LELC_{t-i} + \sum_{i=0}^{q} \alpha_{3i} \Delta LGDP_{t-i} + \sum_{i=0}^{q} \alpha_{4i} \Delta LEGR_{t-i} + \lambda ECT_{t-1} + \varepsilon_t \quad (8)$$

$$\Delta LEGR_t = \beta_{04} + \sum_{i=1}^{p} \alpha_{1i} \Delta LEGR_{t-i} + \sum_{i=0}^{q} \alpha_{2i} \Delta LEGNR_{t-i} + \sum_{i=0}^{q} \alpha_{3i} \Delta LELC_{t-i} + \sum_{i=0}^{q} \alpha_{4i} \Delta LGDP_{t-i} + \lambda ECT_{t-1} + \varepsilon_t \quad (9)$$

3.3. Data Issue

The current paper uses an annual time series data to investigate the relationship between consumption and supply of electricity in South Africa from 1971 to 2015. The data for the variables is collected from World Bank. Since the macroeconomic variables are more likely to carry a random walk, the variables under the study are exposed to stationarity tests and transformed into natural logs to keep the model as simple as possible.

3.4. Unit Root Test

The existing literature suggests that the unit root tests should be tested first to determine the order integration of the variables. The present study employed Augmented Dickey-Fuller (ADF) (Dickey and Fuller, 1981), Phillips and Perron (1988) (PP), and KPSS test proposed by Kwiatkowski et al. (1992). The null hypothesis for ADF AND PP tests is that the series is not stationary. While the null hypothesis for KPSS test is opposite ADF and PP test. Table 1 and 2 present the unit root test, and the unit root tests are run at constant, and trend and constant. All the variables are stationary at 1[st] difference, but gross domestic product is also stationary at level using all selected three tests of stationary under the study. Therefore, gross domestic product is integrated of order I(0), and the other three variables are integrated of order I(1).

Table 1: ADF and PP Test

Variables	ADF				PP			
	Constant		Constant and Trend		constant		Constant and Trend	
	Level	Δ	Level	Δ	Level	Δ	Level	Δ
LGDP	−4.12***	−6.63***	4.3098***	−6.56***	−4.1113***	−21.5805***	−4.1990***	−21.1597***
LELC	−3.1457**	−5.0094***	1.4025	−5.8334***	−3.0744**	−5.0129***	−0.9517	−5.8654***
LEGNR	−2.1162	−7.3496***	2.4135	−8.3192***	−2.0908	−8.2206***	−2.5141	−8.1688***
LEGR	−5.2675	−7.3496***	−5.2675	−7.3496***	−2.5646	−4.5933	−11.2964***	−10.9198***

Source: Authors' computation: The variables are statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively

Table 2: KPSS Test

Variables	KPSS			
	Constant		Constant and Trend	
	Level	Δ	Level	Δ
LNGDP	0.2981	0.5000**	0.1294*	0.5000**
LNELC	0.6836**	0.6044**	0.2009**	0.0583
LNEGNR	0.5598**	0.0993	0.1571*	0.0491
LNEGR	0.7530**	0.2193	0.1093	0.1540*

Source: Authors' computation: significant at (*), (**), (***) represent 10%, 5%, 1% respectively

4. RESULTS AND INTERPRETATION

From Table 2, the results of the KPSS stationarity test shows that LNGDP is stationary at first difference or integrated of I(1) while LNELC, LNEGNR and LNEGR are stationary at level form or integrated of I(0) except for LNEGR that is stationary at first difference on the constant and trend form. The study, therefore, continues to perform the optimal lag that is suitable for the analysis as shown in Table 3 below.

The Table 3 above shows that most of the lag order of selection criteria (FPE, SC, and HQ) choose the 1st lag, therefore, the present study applies the one lag in the variables under the model selection in the next tests.

The present study applied an ARDL bounds test to examine the long run relationship between the variables under the study incorporating Unrestricted Error Correction Model (UECM). The study employs the UECM. The results from the ARDL bounds presented in Table 4. The calculated the F-statistics from the model is greater than the critical values at 1% level of significant suggest that the null hypothesis of no long run relationship cannot be accepted. Since the study found an existence of long run relationship, the short run and long run dynamics between the variables are estimated. The Akaike information criteria (AIC) is used for model selection.

3.5. Cointegrating Equation

D(LGDP) = 12.351054391375 −0.665209939119*(LGDP(−1) − (−0.24625420*LELC(−1) −0.19708921*LEGNR + 4.71892556*LEGR(−1)))

The results of the error correction model (ECM) in Table 5 above reveals a positive statistically significant short run relationship between electricity power consumption and economic growth in South Africa. A 1% increase in electricity consumption in the short run will boost economic growth by 41.30%, ceteris paribus. These results are consistent with the study carried by Bekun et al. (2019). These results contradicts the study carried by Ha and Ngoc (2021). These results means that electricity power consumption is important for economic growth in South Africa. Therefore, policies that leads to increase in electricity consumption must be promoted and implemented to increase the growth of the South African economy.

There is a negative statistically insignificant short run relationship between non-renewable electricity generation and economic growth in South Africa. A 1% increase in non-renewable electricity generation in the short run in South Africa, will insignificantly result in a 0.13% decline in economic growth, ceteris paribus. This means that non-renewable electricity generation in South Africa is not good for the growth of the economy. Therefore, policies that result in a decrease in non-renewable electricity generation in the short run in South Africa should be promoted as this will increase economic growth.

There is a negative statistically significant short run relationship between renewable electricity generation and economic growth in South Africa. This means that a 1% increase in the generation on renewable electricity in the short run will significantly result in economic growth shrinking by 1.84%, ceteris paribus. These results contradicts the study carried by Khobai (2018) that found a positive relationship between renewable electricity and economic growth in South Africa. These results means that renewable electricity generation is not yet good enough for the growth of South African economy. Therefore, policies that reduce renewable electricity generation must be implemented in the short run as this will increase economic growth in South Africa.

The results of the error correction model revealed CointEq(-1) coefficient of -0.67 that is negative and statistically significant with a probability value of 0.0000. This suggest that 65% of the errors in economic growth is corrected within a year. The study continues to estimate the long run relationship among the variables as given in Table 6 below.

The long run estimation for the study is presented on Table 6. Electricity consumption (LNELC) has a negative and insignificant relationship on gross domestic product per capita. A 1% increase in electricity consumption leads to 0.246254% decrease in gross domestic product per capita, when keep other variables constant (the relationship is insignificant). This means in the long run; electricity consumption is detrimental for the growth of South African economy. Therefore, policies that leads to reduction in consumption of electricity in the long run must be promoted to increase economic growth in South Africa.

Table 3: Optimal lag length criterion

Lag	LogL	LR	FPE	AIC	SC	HQ
0	−153.183	NA	0.030431	7.859190	8.028077	7.920254
1	−62.5703	158.5736	0.000733*	4.128516	4.972956*	4.433839*
2	−49.7407	19.88591	0.000882	4.287035	5.807027	4.836616
3	−38.6208	15.01179	0.001203	4.531043	6.726586	5.324882
4	−10.6119	32.21024*	0.000754	3.930598*	6.801693	4.968695

Source: Authors' computation: statistically significant at (*), (**), (***) represent 10%, 5%, 1% respectively

Table 4: ARDL bound Test

F-Bounds Test Null Hypothesis: No levels relationships				
Test Statistic	**Value**	**Signif.**	**I (0)**	**I (1)**
F-statistic	8.448728	10%	2.72	3.77
k	3	5%	3.23	4.35
		2.5%	3.69	4.89
		1%	4.29	5.61

Source: Author's own computation: (*) Significance at 10%, (**) Significance at 5%, (***) Significance at 1%

Table 5: ECM and short run relationship

Variable	Coefficient	Standard Error	t-Statistic	Probability
C	12.35105	2.103348	5.872093	0.0000
D (LELC)	41.29866	8.090332	5.104693	0.0000
D (LEGNR)	−0.131106	0.209580	−0.625565	0.5360
D (LEGR)	−1.836745	1.044376	−1.758701	0.0882
CointEq(−1)*	−0.665210	0.109414	−6.079736	0.0000
R-squared		0.592212		
Durbin-Watson		2.039684		

Source: Author's own computation: (*) Significance at 10%, (**) Significance at 5%, (***) Significance at 1%

Table 6: ARDL long run estimation

ARDL Levels Equation Case 3: Unrestricted Constant and No Trend				
Variable	**Coefficient**	**Std. Error**	**t-Statistic**	**Prob.**
LELC	−0.246254	4.817194	−0.051120	0.9595
LEGR	4.718926	1.874724	2.517130	0.0170
LEGNR	−0.197089	0.325120	−0.606204	0.5487

Source: Author's computation (*) Significance at 10%, (**) Significance at 5%, (***) Significance at 1%

Renewable electricity generation (LNEGR) has a positive and significant relationship on gross domestic product per capita at 5% level of significant in the long run. A 1% increase renewable electricity generation leads to 4.718926% increase in gross domestic product holding other variables constant. This means that renewable electricity generation is good for economic growth in the long run in South Africa. Therefore, policies that result in the increase in renewable electricity generation in the long run in South Africa must be promoted to increase economic growth.

While non-renewable electricity generation (LNEGNR) has a negative and statistically insignificant relationship on gross domestic product per capita in the long run in South Africa. A 1% increase in non-renewable electricity generation in the long run in South Africa, will insignificantly result in economic growth declining by 0.20%, ceteris paribus. This means that non-renewable electricity generation is not good for economic growth in the long run in South Africa. Therefore, policies that leads to a decrease in non-renewable electricity generation in the long run must be promoted and implemented in South Africa to increase economic growth. The study therefore performs the granger causality test as given in Table 7 below to validate the results of the short run and long run relationships.

Table 7: Granger causality test

Null Hypothesis	F-Statistic	Prob
LELC does not Granger Cause LGDP	0.08788	0.7684
LGDP does not Granger Cause LELC	0.09077	0.7648
LEGR does not Granger Cause LGDP	0.36984	0.5465
LGDP does not Granger Cause LEGR	0.73792	0.3954
LEGNR does not Granger Cause LGDP	0.01411	0.9060
LGDP does not Granger Cause LEGNR	0.43109	0.5152
LEGR does not Granger Cause LELC	1.16056	0.2878
LELC does not Granger Cause LEGR	5.74052	0.0213
LEGNR does not Granger Cause LELC	1.44469	0.2364
LELC does not Granger Cause LEGNR	3.88056	0.0558
LEGNR does not Granger Cause LEGR	5.09995	0.0295
LEGR does not Granger Cause LEGNR	0.00196	0.9649

Source: Author's own computation: (*) Significance at 10%, (**) Significance at 5%, (***) Significance at 1%

Table 8: Diagnostic tests

South Africa	Normality	Serial correlation	Heteroscedasticity	Ramsey's RESET test
Statistical Test	0.528863	2.6107769	7.410359	3.236122
Prob-value	(0.7693334)	(0.4556)	(0.4931)	(0.0818)

Source: Author's own computation: (*) Significance at 10%, (**) Significance at 5%, (***) Significance at 1%

The results of the Granger causality test in Table 7 above reveals that electricity consumption granger causes non-renewable and renewable electricity generation. The results further reveal that non-renewable electricity generation granger causes renewable electricity generation. However, electricity consumption, non-renewable electricity generation and renewable electricity generation does not granger causes economic growth in South Africa as revealed by the results in Table 7 above.

The variables under the study are exposed to diagnostic tests for normality, serial correlation, heteroscedasticity, and model misspecification. The study employed Breusch-Godfrey LM. The null hypothesis is that there is no serial correlation. Harvey test is employed to investigate the presence of heteroscedasticity. The null hypothesis for the test is homoscedasticity meaning that the variance of the error term is constant. To ensure that model is correctly specified Ramsey (1969) test is employed by the

Figure 3: CUSUM test

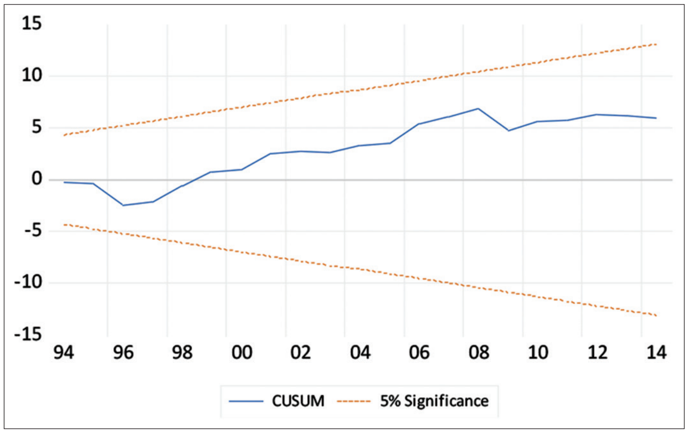
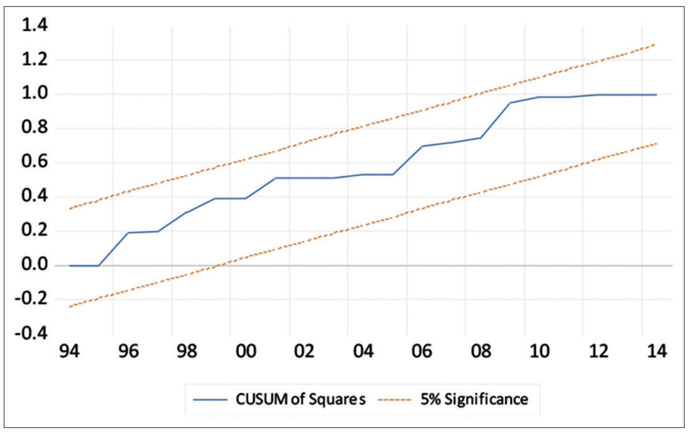


Figure 4: CUSUM of squares test



Source: Authors' computation: The variables are statistically significant at (**) represent 5%

present study. The null hypothesis is that the model is correctly specified. The Jarque and Bera (1980) test is recruited to check for the normality of the residuals. The results for diagnostic tests are presented in Table 8. The results demonstrates that there is no evidence of serial correlation, heteroscedasticity, and model misspecification since the null hypotheses are not rejected. According to the results presented in Table 8, the residuals are normally distributed since null hypothesis of normality of residual is not rejected.

The study further tests for stability of coefficients using the cumulative sum of recursive residuals (CUSUM) test and CUSUM of squares test. The graph for CUSUM test and CUSUM of squares test are presented in Figures 3 and 4 respectively. The Figures 3 and 4 for CUSUM indicate model stability as plots are within the 5% confidence interval.

5. CONCLUSION AND RECOMMENDATIONS

The study's main goal was to investigate the impact of electricity consumption and supply on economic growth in South Africa utilizing borrowed yearly time series data spanning the years 1971 to 2014. The unit root test (ADF, PP, and KPSS), lag length criterion, ARDL bounding test to cointegration, Error Correction Model (ECM), and diagnostic tests (residual and stability tests) were used to achieve the aim. The unit root revealed that the variables are a mix of integration, with LGDP integrated of I(0) and other variables (LELC, LEGNR, and LEGR) integrated of I(1), indicating that the ARDL model is appropriate for use in the research.

The empirical results revealed a positive statistically significant short run relationship between electricity consumption and economic growth in South Africa. In the long run, the relationship between electricity consumption and economic growth was found to be negative and statistically insignificant. The relationship between non-renewable electricity and economic growth was found to be negative statistically insignificant both in the short and long run period. Renewable electricity was found to be negative statistically significant in the short run and positive statistically significant in the long run period. The speed of adjustment was found to be 67%, meaning if there is any deviation from equilibrium the 67% economic growth is corrected within a year. The granger causality test revealed no causality between non-renewable and renewable electricity on economic growth.

Based on empirical results, it can therefore be recommended that: Firstly, there is a need to avoid continuous power cuts or load shedding as it is detrimental to economic growth. This is reasonable because almost every economic activity needs electricity power to be done. From primary sector, secondary sector and tertiary sector electricity is a necessity meaning if there are continuous power cuts, then this will transform into economic growth declining dismally as these sectors will not be able to perform to their full levels.

Secondly, the positive and significant long run relationship between renewable electricity and economic growth calls for policy makers to propose and implement policies that promotes renewable electricity. The government also must increase its investments in building more renewable electricity powerplants so that they can increase economic growth and help reduce the problem of continuous power cuts.

Thirdly, there is a need to evaluate policies of non-renewable electricity since it is detrimental to economic growth in both the short and long run period. This negative relationship might be to the reason of backlog, lacking adequate maintenance and poor coal supplies in those non-renewable electricity powerplants. The government therefore need to maintain the old generators properly and timeously so they can perform to the full capacity and positively contribute to economic growth.

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