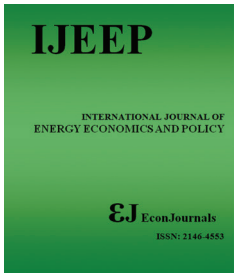

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An Investigation into the Electricity Supply and Economic Growth Nexus for South Africa

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ABSTRACT

A booming industrial sector helps to complement and sustain continued economic growth. On the other hand an efficient and steady supply of electricity is of paramount importance for the growth of an industrial sector of a country as it acts as catalyst for economic growth. The study sought to examine the causal relationship between electricity supply and economic growth in South Africa for the period 1990-2012. The study incorporated electricity power outages and employment to form a multivariate framework using a vector error correction model. The study established a unidirectional causality flowing from electricity supply to economic growth. The result implies that electricity supply boosts economic growth in South Africa. There is need for the policy makers to ensure they put in place measures that can improve the electricity supply in the country through a reduction in power outages for the industrial sector.

Keywords: Electricity Supply, Economic Growth, Causality Test, Nexus
JEL Classifications: C22, O13, Q14

1. INTRODUCTION

Electricity is a vital form of energy. Electricity supply security is crucial as it ensures the continued supply of electricity for a well-functioning industrial process. The importance of electricity supply to economic growth was realised in the period between 1902 and 1912 when data on electricity demand and supply was made available (Martins, n.d). The use of electricity increased with time such that between 1920 and 1929 the consumption of electricity per unit of gross national product doubled the 1902 to 1920 values (Martins, n.d.). A slight decline was experienced after the World War II (Martins, n.d.). These trends showed that electricity usage followed the same trend as the economic growth in the USA. This observation invoked the researchers' attention to start analysing the relationship between electricity consumption and economic growth with a view to establish the relationship between electricity supply and economic growth.

The study of the nexus between electricity supply and economic is important in today's world because of the fluctuating energy prices, environmental problems, energy security, climate change, and energy dependency. South Africa has been identified in the continent as the largest emitter of greenhouse gas emissions. South Africa accounts for approximately 42% of the emissions in the whole continent (Kohler, 2013). It is believed that 92% of electricity is produced from coal resulting in the country's high carbon emissions intensity (Inglezi-Lotz, and Blignaut, 2011). The use of coal as the main source of electricity generation has failed the country post the apartheid era where demand for electricity outstripping supply as a result of economic growth. Since electricity supply did not increase proportionately, this then led to the rationing of electricity by Eskom (the national electricity producer) in 2008. The policy measures implemented to conserve electricity only worked in the short run. The country continued to experience the power outages from 2014. Thus, the knowledge of the direction of causality between electricity supply and economic growth is crucial for South Africa to determine appropriate energy policies.

The main objective of this paper is to establish the nexus between economic growth and electricity supply in South Africa for the

period 1990-2012. The study employs the vector error correction model (VECM) using quarterly time series data for South Africa. This study is complementary to the previous studies for South Africa (Wolde-Rufael, 2009, Kohler, 2013, Menyah and Wolde-Rufael, 2010). The majority of these studies concentrated on establishing the causal relationship between energy consumption and economic. This study discusses discuss the causal relationship between electricity supply and economic growth. The study incorporates into the model the power outages and employment levels following Ellahi (2011) for Pakistan economy.

The rest of the paper is structured as follows: Section 2 review the literature; Section 3 outlines the study methodology and Section 4 presents and analyses the results. Policy conclusions and recommendations are discussed in Section 5.

2. LITERATURE REVIEW

There are a number of studies that has sought to determine the relationship between electricity and economic growth (Muhammad et al., 2012; Atif and Siddiqi, 2010; Bekhet and Othman, 2011; Michieka, 2015; Khobai et al., 2016; Sharmin and Khan 2016). These studies are a result of the fact that electricity is among the many factors important in the production processes. It is believed that electricity is among the catalyst for economic growth. The studies on the causal relationship between electricity consumption and economic growth has generated a lot debate since the results from the studies have differed widely. Among these studies; Muhammad et al. (2012) for Kazakhstan, Atif and Siddiqi (2010) for Pakistan, Bekhet and Othman (2011) for Malaysia established that electricity consumption granger-causes economic growth. Similar results were established for Botswana (Adebola, 2011) and Nigeria (Ankilo, 2009) for African economies. Similarly the one way causality from economic growth to electricity consumption was established in other studies; Yoo and Kim (2006) for Indonesia; Jamil and Ahmad (2010) for Pakistan; Smyth and Lean (2010) for Malaysia; Masuduzzaman (2013) for Bangladesh; Akinwale et al. (2013) for Nigeria and Inglesi-Lotz et al. (2013) for South Africa; Sharmin and Khan (2016) for Angola. There are a number of studies that failed to establish any causal relationship between electricity consumption and economic growth (Akpan and Akpan, 2012) for Nigeria and Ghosh (2009) for India). A feedback back hypothesis was revealed in the following studies; (Ouedrago, 2009; Tang, 2008; Ahmad and Islam, 2011; Odhiambo, 2009; Shahbaz and Lean, 2012; Solarin and Shahbaz, 2013; Ahmad, et al., 2013; Sharmin and Khan 2016).

There has also been a number of multicounty studies that have been undertaken. Squalli (2007) investigated the relationship between economic growth and electricity consumption for the Organisation of Petroleum Exporting Countries. A unidirectional causality flowing from electricity consumption to economic growth was found in Indonesia, Iran, Nigeria, Qatar and Venezuela. The results revealed no causal relationship between electricity consumption and economic growth for Kuwait, Saudi Arabia and UAE. Wolde-Rufael (2006) conducted a study for 17 African countries to determine the causal relationship between electricity consumption and economic growth. His findings indicated that the granger-causality results are found in 12 countries while the rest failed to find granger-causality relationship between economic growth and electricity consumption. Apergis and Payne (2011) considered 88 countries categorised into high, upper middle, low middle and low income countries. Their results indicated that for high income and upper-middle income countries, there is a bidirectional causality flowing between electricity consumption and economic growth while the lower income countries' results suggested a unidirectional causality running from electricity consumption to economic growth.

There are a few studies that has been carried out to investigate the granger-causality relationship between electricity supply and economic growth. Ghosh (2002) discovered a unidirectional causality flowing from electricity supply to economic growth in India. Similar results were found by Gupta (2009) for India, Sarker (2010) for Bangladesh and Nanaji et al. (2013) for Nigeria. Smyth and Lean's (2010) suggests a one-way causality flowing from economic growth to electricity supply in Malaysia. Bidirectional causality flowing between electricity supply and economic growth was established in Portugal (Cerdeira, 2012).

The reviewed literature shows that the study of the nexus between electricity supply and economic growth is inconclusive. This motivate the current study to establish the same for the South African economy. The researchers are not aware of any study that has been done in South Africa to investigate the causal relationship between electricity supply and economic growth which incorporate power outages and unemployment levels hence the contribution to theory of this current study.

3. RESEARCH METHODOLOGY

The study uses the extended neoclassical production function where technology is endogenously determined by power outages and employment. The general form of this production function therefore is a follows:

$$GDP_t=\alpha_1+\alpha_2 DUM08+\alpha_3 ES_t+\alpha_4 EM_t+\varepsilon_t \quad (1)$$

Where; *GDP* represent the real gross domestic product (using constant prices of 2005), *DUM08* is the dummy variable for the power outages from 2008, *ES* is the electricity supply measured in Gigawatt-hours and *EM* is the total labour force. The research's model is different from Ghosh's (2009) model in that it includes a dummy variable on electricity outages. The year 2008 is chosen because that is when South Africa experienced high levels of power outages. It has been observed in the literature that power outages have a significance influence on real GDP hence, its inclusion in the model. The choice of power outage dummy variable also follows from Ellahi's (2011) study which used a model with a dummy variable of power outages from 2007. Ellahi's (2011) study evidenced that power outages affect economic growth. The variables are all expressed in logarithmic form to stimulate stationarity of the mean, variance and covariance as a result reducing heteroscedasticity (Acaravci and Ozturk, 2010).

The empirical study uses quarterly data for the period 2000 quarter one to 2012 quarter 2. The data for South African GDP

is sourced from the South African Reserve Bank while data for Labour is found from IMF international financial statistics. In the research, electricity generation is expressed in terms of Gigawatt hours and it is obtained from the Statistics South Africa data base. The nominal GDP of South Africa is deflated by the GDP deflator to compute the figures for real GDP taking 2005 as the base year. Following the studies by Narayan and Smyth (2005) and Odhiambo (2009) labour is calculated as the total number of people who are employed in the manufacturing industry. The research also included people employed in the mining and manufacturing sectors because it also employs a significant amount of labour in South Africa.

The paper starts by examining the stationarity of each series to avoid obtaining spurious results. Two methods are employed to establish the stationarity of the variables; Augmented Dickey Fuller (ADF) unit root test and Phillips Perron (PP) unit root test.

The presence of co-integration relationship indicates the existence of causal relationship but does not show the direction of causality between the variables. Madhavan et al. (2010) indicated that the granger-causality as a vector autoregressive is applied in the first differenced form if the variables were not co-integrated. On the other hand, if the variables are co-integrated, the granger-causality which entails the lagged error correction term (ECT) is used in the equation as an additional variable. The information pertaining to long run relationship between the variables is contained in the ECT while the short run information is determined by the lagged terms of individual coefficients (Adebola, 2011). Adebola (2011) further shows that the long run relationship is depicted by a negative sign on the coefficient of the ECT. For the purpose of the research, the following equations will be used.

$$\Delta LGDP_t = \alpha_{10} + \sum_{i=1}^{q} \alpha_{11} \Delta LGDP_{t-i} + \sum_{i=1}^{r} \alpha_{12} \Delta LES_{t-i} + \sum_{i=1}^{s} \alpha_{13} \Delta LEM_{t-i} + \psi_1 ECT_{t-1} + \varepsilon_{1i} \quad (2)$$

$$\Delta LES_t = \alpha_{20} + \sum_{i=1}^{q} \alpha_{21} \Delta LES_{t-i} + \sum_{i=1}^{r} \alpha_{22} \Delta LGDP_{t-i} + \sum_{i=1}^{s} \alpha_{23} \Delta LEM_{t-i} + \psi_2 ECT_{t-1} + \varepsilon_{2i} \quad (3)$$

$$\Delta LEM_t = \alpha_{30} + \sum_{i=1}^{q} \alpha_{31} \Delta LEM_{t-i} + \sum_{i=1}^{r} \alpha_{32} \Delta LGDP_{t-i} + \sum_{i=1}^{s} \alpha_{33} \Delta LES_{t-i} + \psi_3 ECT_{t-1} + \varepsilon_{3i} \quad (4)$$

The direction of causality can be differentiated between long run and short granger-causality effects. The *t*-statistics is used to test the significance of the lagged *ECT*. The significance of *ECT* will prove the existence of long run granger-causality (Ghosh, 2009). The short run granger-causality is tested by the F-statistics and testing the significance of the lagged independent variables (Odhiambo, 2009).

4. RESULTS AND ANALYSIS

The study starts by undertaking unit root tests to establish the stationarity of the variables. Table 1 presents the unit root tests findings which indicate that all the variables are not significant at the level form. Thus, the null hypothesis, whereby the variables have unit root cannot be rejected. This in turn implies that the variables are not stationary in levels. The variables are stationary after first differencing implying the variables are integrated of order one.

After testing for the stationarity of the variables, the study employs the VECM to determine the direction of causality among the variables. The results are presented in Table 2.

The F-statistics on the lagged coefficients of the independent variables of the ECM indicate the significance of the short-run causal effect (Narayam and Smyth, 2005). The t-statistics on the coefficients of the lagged ECT indicates the significance of the long run causal effect.

The coefficient of the ECT in this case is shown to be significant at the 5% level of significance but has a positive sign. This means that there is no long run causality flowing from real GDP, employment and power outages to electricity supply. The results also failed to show short run causality.

The results further present the coefficient of the lagged error term which is used to determine the existence of the long run causality between the variables. The coefficient of the lagged error term shows the speed of adjustment of the endogenous variables to explanatory variables and determines the long run causality. It has to be negative and significant to suggest existence of long run causality. Table 2 illustrates that the coefficient of the lagged error term is negative and significant. This suggests that there is a long run causality flowing from electricity supply, employment and power outages to real GDP. This implies that there is no short run casualty established.

The overall results shows that there is no short run causality flowing from either electricity supply to economic growth or from economic growth to electricity supply. The absence of a short run causality flowing from electricity supply to economic growth imply that environmentally friendly policies like electricity conservation, the demand-side management policies and efficiency improvement measures, can be implemented without adversely affecting economic growth.

The results in Table 3 suggest that there is a long run causality running from power outages and employment to economic growth. The most important findings in the granger causality is that electricity supply granger-causes economic growth without any feedback. This means that the energy conservation policies will cause harm to economic growth in the long run if they are implemented in South Africa.

The stability of the VAR model is tested using the unit circle in Figure 1. The results show that all the lagged variables fall within the unit circle. This provides evidence of the stability of the VECM model.

Table 1: Results for unit root tests

VAR	ADF				PP			
	Intercept		Intercept and trend		Intercept		Intercept and trend	
	Level	Δ	Level	Δ	Level	Δ	Level	Δ
GDP	−0.802	−3.089*	−1.913	−3.100*	−0.906	−3.574**	−1.246	−3.081**
ES	−1.717	−17.66*	−0.615	−18.031**	−2.451	−9.724*	−4.1349	−13.014*
EM	−1.293	−6.875*	−1.767	−6.814*	−1.297	−6.888*	−1.767	−6.822*

*.**Represent significance at 1% and 5% levels respectively. The null hypothesis is that the variable has a unit root. VAR: Vector autoregressive, ADF: Augmented dickey fuller, PP: Phillips and perron, GDP: Gross domestic product, EM: Employment, ES: Electricity supply. Source: Author's own calculations

Table 2: VECM granger-causality analysis

Long run granger-causality			
Dependent variable	ECT	Sign of ECT	P
Real GDP	0.0583	Negative	0.0000*
Electricity supply	0.0199	Positive	0.0443**
Employment	0.0076	Negative	0.8214

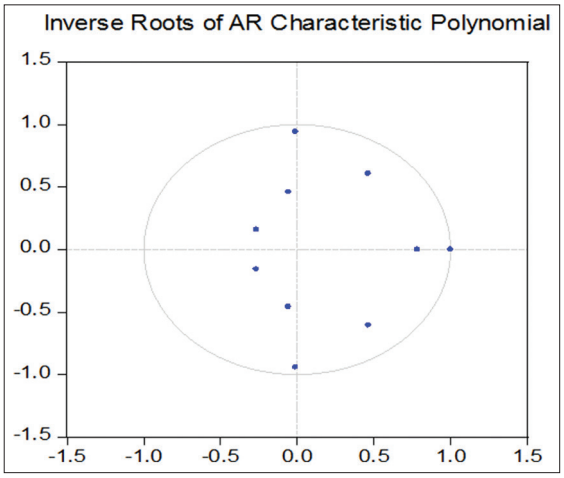
*.**Represent significance at 1% and 5% levels respectively. ECT: Error correction term, GDP: Gross domestic product, VECM: Vector error correction model

Table 3: VECM granger-causality analysis

Short run granger-causality		
Hypothesis	Chi-square	Probability values
ES does not granger cause RGDP	10.9938	0.0041*
EM does not granger cause RGDP	0.7568	0.6850
PO does not granger cause RGDP	19.8377	0.0000*
RGDP does not granger cause ES	0.7319	0.6935
EM does not granger cause ES	3.9493	0.1388
PO does not granger cause ES	1.3856	0.5002
RGDP does not granger cause EM	5.2794	0.0714***
ES does not granger cause EM	0.3571	0.8365
PO does not granger cause EM	0.0397	0.9804

PO: Power outages. *.***Show significant at 1% and 10% level. Source: Author's Own calculations, GDP: Gross domestic product, VECM: Vector error correction model, EM: Employment, ES: Electricity supply

Figure 1: Unit circle



5. CONCLUSION AND POLICY RECOMMENDATION

This study examined the causal relationship between economic growth and electricity supply by incorporating electricity power outages and employment as the intermittent variables. To achieve the objective of this study, unit root and granger-causality models were applied to South African quarterly data for the period running from the first quarter of 2000 to the second quarter of 2012.

From the ADF unit root and PP unit root tests, it was established that all the variables are not stationary at the level form but stationary at first difference. The findings from the VECM indicated that power outages granger-causes economic growth. It was further revealed that employment also granger-causes economic growth. Most importantly, the findings suggested a one-way causality flowing from electricity supply to economic growth in the long without any feedback. However, there was no short run causality found flowing from either electricity supply to economic growth or from economic growth to electricity supply.

From the results obtained in this study, it is recommended that the electricity conversation policies should not be applied in the long run as they will harm South Africa's economic growth. However, the policy makers should concentrate on increasing the investment in electricity supply projects to enhance electricity generated in the country. In addition, it is important to apply the energy conservation policies in the short run as they will not adversely affect economic growth. By applying this recommendation, South Africa would be able to mitigate the persistent power outages and use the scarce resources to improve their power supply. This will boost the economic growth.

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