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Economic Growth and Electricity Consumption in a Multivariate Framework: A Case of Zimbabwe 1980 to 2016

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Abstract: Electricity is important for sustainable development as it enhances productivity, employment and general living standards of people. The paper investigates the relationship between electricity consumption and economic growth in a multivariate framework for the period 1980 to 2016 in Zimbabwe. The study builds on previous bi-variate studies on electricity consumption and economic growth nexus. Specifically, the study applies both granger causality tests and single step error correction model to study the relationship between electricity consumption, economic growth and investment. The Granger causality tests confirm the existence of a bi-directional causality between electricity consumption and economic growth. This implies that in Zimbabwe, electricity growth results in increased economic growth and vice versa. Electricity also granger causes investment in Zimbabwe. The study shows that there is a long run relationship between electricity, investment and economic growth in Zimbabwe. The results suggest that consumption of electricity is a prerequisite and a binding constraint to achieving higher economic growth in Zimbabwe. In order to boost economic growth, the country needs to profoundly invest in electricity infrastructure.

Keywords: Economic growth; Electricity consumption; Investment; Multivariate; Zimbabwe

JEL Classification: E22; C22; O47

1. Introduction

The Zimbabwean economy rebounded in 2009, after experiencing a decade of economic decline. The economy is estimated to have registered an average economic growth rate of 9% for the period 2009 to 2013 (ZIMSTAT, 2017). The economy benefited mainly from the introduction of multiple currency exchange rate system and liberalisation of prices in all sectors of the economy. Economic growth, however,

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slowed down in 2014 and it averaged 1.5% between 2014 and 2016. The inherent structural challenges, in particular electricity and other infrastructure challenges have resulted in slowdown in economic growth in 2014. The availability of electric power in the country has been erratic in the last decade with most parts of Zimbabwe experiencing occasional and prolonged outages of electricity. In 2016, the country was producing between 1,100 to 1,300 MW a day out of a total installed capacity of 1,960MW. This was against a national demand of 1,800MW and a peak demand of 2,100MW. Electricity generation was augmented by 100 MW to 200 MW imports from regional countries such as Mozambique, Democratic Republic of Congo (DRC), Zambia and South Africa.

Research gap and contribution of the study: Not many studies have been done on the relationship between electricity and economic growth in Zimbabwe. Most studies on the electricity and economic growth nexus in Zimbabwe have been carried out as part of regional studies, focusing on Zimbabwe as part of African countries (Wolde, 2006), Sub-Sahara Africa (Akinlo, 2008) and Common Market for Eastern and Southern Africa (COMESA), Nondo, et al (2010). The results from these studies have been conflicting. However, most studies reveal that the relationship runs from economic growth to electricity in Zimbabwe. These studies lack an in depth analysis of the electricity situation in Zimbabwe. In addition, using per capita electricity consumption is not quite representative of the electricity that goes into production in Zimbabwe as a larger proportion of the country's populace lives mainly in the rural areas with no access to electricity. The country's electricity consumption is mainly prioritised towards production activities in manufacturing, mining and agriculture. As argued by Wolde-Rufael, (2009) a detailed study on the relationship between electricity and economic growth is required in Zimbabwe.

It is against this background, that this study seeks to examine the link between electricity and economic growth in Zimbabwe from 1980 to 2016. This study expected to further the study between electricity and economic growth in Zimbabwe, the subject that has hitherto been done on a peripheral basis. Crucial, also is to investigate the causality between electricity and economic growth. The examination of the direction of causality is critical and has implications for electricity development and regulation policy.

Organization of the paper: The remainder of the paper is organised into seven sections. Section 2 presents the electricity industry structure and recent developments in electricity generation and consumption in Zimbabwe. Section 3 discusses both theoretical and empirical literature review on electricity consumption and economic growth. Section 4 provides the research methodology. Section 5 discusses the results while Section 6 summarises the study and proffer policy recommendations. Section 7 provides the references list.

2. Stylised Facts: Electricity Industry Structure, Electricity Generation and Consumption in Zimbabwe

2.1. Trends in Zimbabwe Electricity Generation

Zimbabwe's generation capacity has declined significantly as a result of the inability to replace obsolete equipment at most generation stations. The country's reliable capacity has been around 1,100 MW in 2016 against an installed capacity of 1,920 MW and National Demand of over 2,200 MW. This demands for huge investments to be made in order to increase the amount of reliable capacity. Notably, this should be made available at competitive prices, which are affordable to consumers as well as ensuring the electricity providers recoup their costs. Figure 1 below shows electricity generation trends in Zimbabwe for the period 1985 to 2016.

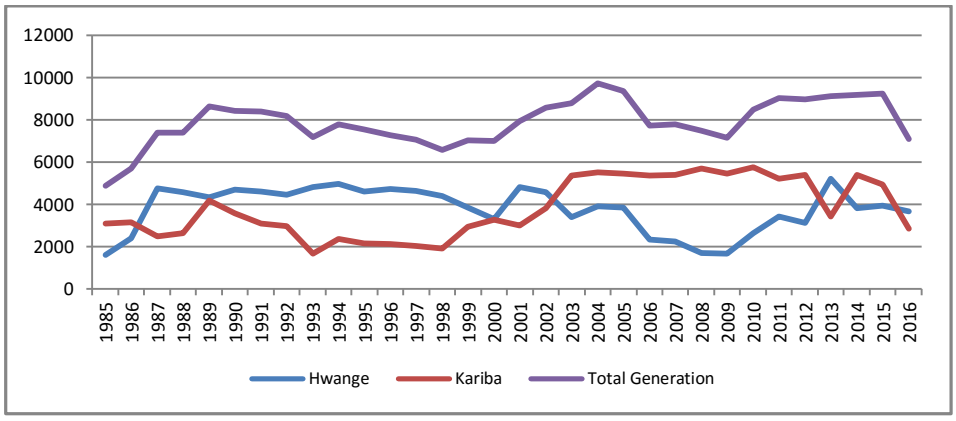

Figure 1. Electricity Generation: 1985-2016

Source: ZIMSTAT, 2017

Figure 1 shows that electricity generation fell from 8,393 GWh in 1991 to 6,582 GWh in 1998, before peaking at 9,719 GWh in 2004. Electricity generation, however, progressively declined to 7,165 GWh in 2009 and has been on a slow recovery since then. Resultantly, electricity generation recovered to 9,815 GWh in 2014 but declined to 7,090 GWh in 2016.

2.2. Electricity Consumption

Major consumers of electricity in Zimbabwe are domestic consumers, manufacturing and mining companies and farmers. It is critical to note that electricity consumption by these major consumers, save for domestic consumers, has been on a decline since 2002. The consumption of electricity by farmers declined significantly since 2006, reflecting on the impact of the Fast Track Land Reform Programme (FTLF). The land resettlement programme replaced large commercial farmers with small scale farmers who use minimal electricity powered mechanised farming equipment.

Figure 2 shows developments in electricity consumption by major players in the economy.

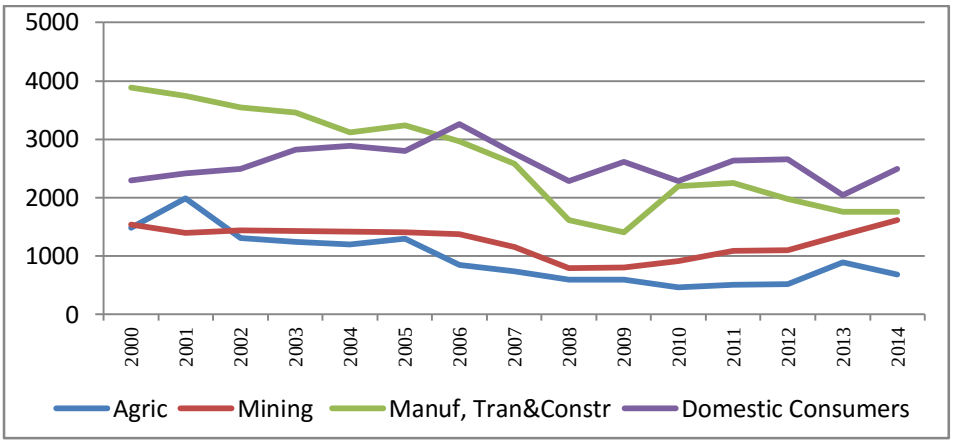

Figure 2. Electricity Consumption by Major sectors (GwH)

Source: ZIMSTAT, 2017

There has been a sustained growth in electricity consumption by the mining sector from 2009. Consumption of electricity in the agricultural sector has been on a rise from 2009 to 2013, but fell slightly in 2014 while electricity consumption in the manufacturing sector has been on a decline since 2012.

3. Literature Review

The role of electricity consumption in economic growth started with the seminal work of Kraft and Kraft (1978). Policy makers have acknowledged the role played by the electricity infrastructure in supporting economic development particularly in developing countries. Adequate and uninterrupted electric power supply is one of the key determinants of stimulating economic growth for any economy. Mainly, four broad hypotheses have emerged and these include the growth, conservation, feedback and neutrality hypotheses. The policy stance to be adopted should, therefore, to a large extent be based on these four possible hypotheses.

The growth hypothesis purports that electricity consumption unilaterally leads to economic growth. These studies focus primarily on developing economies. The unidirectional causality between electricity consumption and economic growth seems to be more consistent for these countries. The conclusion is that a reliable electricity supply is required to meet the ever increasing electricity consumption, and as a result to sustain paths of economic growth.

The conservation hypothesis occurs when economic growth unilaterally leads electricity consumption. The main policy recommendation from this result is that a modest level of electricity consumption cannot impede economic growth. The third hypothesis is the feedback hypothesis which prevails when there is a double causality between electricity consumption and economic growth. In this case, it means the growth causes electricity consumption while simultaneously, electricity consumption also causes economic growth. The policy thrust should, therefore, address both electricity consumption and economic growth. The last case is the neutral hypothesis, this is when there exists no causal relationship between electricity consumption and economic growth. This, implies that economic growth is independent from electricity consumption. It is important to note also that the impact of electricity consumption on economic growth is also a function of the users. The users of electricity consumption such as industry, residents or commercial will have different impacts on economic growth. For example, in Zimbabwe, major electricity consumers are mainly from manufacturing, mining and agriculture sectors. The impact of electricity consumption on these three sectors is expected to have more impact on economic growth than the rest of economy.

In light of the possible four hypotheses highlighted above, it appears that from a theoretical standpoint, it is important to determine the direction of the causal relationship between electricity consumption and economic growth. Typical developing economies consume more electricity as they develop and diversify from traditional primary sectors such as mining and agriculture to high electricity intensity manufacturing sector. Concomitantly, increased use of energy brings efficient gains in the production processes, thereby, supporting increased economic growth.

Several studies have been done on the electricity and economic growth nexus, although the result on the direction of causality is not conclusive. Importantly, however, most researches depicted that there exists a strong relationship between electricity consumption and economic growth, the earliest studies being, Kraft and Kraft (1978), Akarca and Long (1980), Proops (1984), and Yu and Hwang (1984).

The empirical studies that have found unidirectional causality running from electricity consumption to GDP include Altinay and Karagol (2005) for Turkey, Chien-Chiang & Chun-Ping, (2005) for Taiwan and Salman, Asghar, Kahlon and Chughtai (2013) Important studies for the causality running from growth to electricity include Ghosh (2002) for India, Fatai et al. (2004) for New Zealand and Australia and Hatemi and Irandoust (2005) for Sweden. The feedback hypothesis or bi-directional causality was found in studies by Soytas and Sari (2003) for Argentina, Oh and Lee (2004) for Korea, Jumbe (2004) for Malawi, Pata and Terzi (2017) for France, Italy and UK and also Mozumder and Marathe, (2007) for Bangladesh.

Rashid (2015) incorporated financial development to reduce the problem of omitted variable bias on the relationship between electricity and economic growth in

Pakistan. The results suggest a bi-directional relationship where electricity cause GDP and vice versa. Financial development was also found to be key in raising electricity consumption. Relatedly, Rahmani, Roshani and Kalaee (2016) shows the importance of energy in stimulating GDP in Iran.

Several studies on the relationship between electricity consumption were also done in Africa. Iyke and Odhiambo (2014) investigated the relationship between electricity consumption and economic growth in Ghana using an ARDL framework, for the period 1971–2012. They used a 3 variable framework to avoid the problem of variable omission bias by including inflation in addition to electricity consumption and GDP. They concluded that there is a growth-led relationship, running from economic growth to electricity consumption in the short run and in the long run. Adom (2011) examined the direction of the causality between electricity, and economic growth using a two variable framework as well as Granger Causality from 1971 to 2008. Adom (2011) concluded that there is a unidirectional causality running from economic growth to electricity consumption, in line with results of Iyke and Odhiambo, (2014).

Ubi and Effiom (2013) also undertook the study of the relationship between electricity supply and economic development in Nigeria using annual time series data. The researchers used a multivariate case, modifying a typical production function and concluded that electricity influences economic development in Nigerian, albeit on a low scale. Enu and Havi (2014) investigated the electricity-economic growth nexus in Ghana using a typical production function with electricity, labour and capital is explanatory variables for GDP in a Vector Error Correction Model framework. They concluded that there is a unidirectional causality run from electricity consumption to economic growth. Enu and Havi (2014) findings show that in the long term, a 1 percent increase in electricity power consumption results in a GDP per capita increase of 0.5 percent.

Ogundipe and Apata (2013), examined the causal relationship between electricity consumption and economic growth in Nigeria by using a modified Cobb-Douglas function for the 1980-2008. They utilised a Vector Error Correction Modelling and the Pairwise Granger Causality test. The study found electricity consumption positively and significantly impact on growth. Notably, the study found a bi-directional causal relationship flowing from electricity consumption and economic growth. Akomolafe and Danladi (2014) used a multivariate framework to study the relationship between electricity consumption and economic growth in Nigeria from 1990 to 2011. The study included capital and labour as additional variables. They concluded that there is a unidirectional causality from electricity consumption to real gross domestic product.

Few studies were done to ascertain the relationship between electricity and economic growth in Zimbabwe. Notable studies include Wolde-Rufael (2006, 2009), Akinlo,

(2009) and Nondo, et al (2010). Wolde-Rufael (2006) studied the relationship between electricity and economic growth in Zimbabwe using data from 1971 to 2001. The study was done as part of the research on the experience of 18 African countries. A unidirectional causality running from economic growth to electricity was obtained in Zimbabwe. The study used a bi-variate approach. Wolde-Rufael (2009) re-examined the relationship between electricity and economic growth in the African countries, including Zimbabwe utilising a multivariate framework by including labour and capital as additional variables. The study obtained the bi-directional relationship between electricity and economic growth in Zimbabwe.

Akinlo (2008) examined the relationship between energy and economic growth, using an autoregressive distributed lag (ARDL) bounds test 11 sub Saharan countries, Zimbabwe included. The study found out that a long run relationship between energy consumption and economic growth existed for Zimbabwe. In addition, he also noted that economic growth granger cause energy consumption in Zimbabwe. In another study, Nondo, et al (2010) examined the relationship between energy consumption and economic growth for 18 COMESA countries including Zimbabwe. The study utilised panel estimation techniques. The study concluded that a bi-directional causality relationship existed between energy consumption and GDP in COMESA.

4. Research Methodology

The bivariate and multivariate approaches are the two main approaches that can be used to analyse the causality between GDP and electricity consumption. However, a common problem associated with bivariate analysis is the possibility of omitted variable bias, which draws into question the validity of the inferences of a causal relationship. This study utilises the multivariate approach in examining the relationship between GDP and electricity in a typical modified production function. In this regard, multivariate model includes GDP, electricity, labour and capital.

The general endogenous production function is given by

$$Y = Af(K,L) \quad (1)$$

where:

Y = Real GDP; A = Total factor productivity; K = Capital stock; = labour

The study attempts to estimate the impact of electricity on economic growth. Electricity is assumed to affect economic growth through its impact on total factor productivity. In this regard, the production function can be re-written as

$$Y = f(K, L, E) \quad (2)$$

where:

E = Electricity consumed in the economy.

By dividing throughout by L to reduce to output per worker, equation [2] becomes

$$Y/L = f(K, E) \quad (3)$$

In this regard, the actual model utilised in the study is specified as:

$$Gdpl = f(Eused, Inv) \quad (4)$$

where:

Gdpl is GDP per worker; Eused = electricity consumption in the economy; and Inv is gross fixed capital formation which is used to proxy capital formation.

The data was transformed into logarithms and causality testing in the Granger sense is conventionally conducted by estimating autoregressive or vector autoregressive (VAR) models. As highlighted by Bahmani-Oskooee and Alse, (1993), if the variables are co-integrated the standard Granger Causality test results will be invalid. To augment the granger causality analysis and allow for policy analysis, both long and short term elasticities estimates for electricity and investment are done.

Data description: The study used time series data of total electricity consumption, real GDP per worker and gross fixed capital formation from 1980 to 2016. Electricity consumption is the total electricity which is consumed by the final users including industry and domestic residents. Electricity consumption is normally well below electricity generation and electricity distributed. This reflects electricity imports and exports as well as transmission losses incurred as power is delivered to final users. Electricity consumption data was obtained from Zimbabwe National Statistical Agency (ZIMSTAT) quarterly digest. Real GDP per worker was found by dividing real GDP by the total actual number of workers employed in the economy. Employment levels in the economy were extracted from the ZIMSTAT Quarterly Employment Enquiry (QES) while GDP figures were extractedfrom the ZIMSTAT quarterly digests. Capital is proxied by gross fixed capital formation and this was obtained from the quarterly digests from ZIMSTAT.

5. Empirical Results

As a preliminary analysis, the statistical properties of the data were assessed using unit root tests and Johansen cointegration tests. The number of lags was selected by the Akaike information criterion (AIC).

Unit Root Tests

The unit root test results obtained from Augmented Dickey Fuller tests are shown in Table 1.

Table 1. Unit Root Tests

Variable	**Level**	**First Difference**
Electricity Consumption	-1.8596 (0.3466)	-4.6005*** (0.000)
Investment	0.3124 (0.9976)	-8.4800*** (0.000)
GDP	-3.0334*** (0.1414)	-4.0514*** (0.0036)

Source: Authors' Computation

The unit root test results show that all the variables are stationary after first differencing.

Cointegration Tests

The Trace and Eigenvalue tests suggest that the variables used are cointegrated. The results are shown in Table 3 and Table 4 respectively.

Table 2. Unrestricted Cointegration Rank Test (Trace)

Hypothesized		Trace	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.526050	31.84326	29.79707	0.0287
At most 1	0.265935	9.443636	15.49471	0.3259
At most 2	0.005614	0.168898	3.841466	0.6811
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				
Table 3: Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob.**
None *	0.526050	22.39962	21.13162	0.0330
At most 1	0.265935	9.274738	14.26460	0.2640
At most 2	0.005614	0.168898	3.841466	0.6811
Max-eigenvalue test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
**MacKinnon-Haug-Michelis (1999) p-values				

Source: Authors' Computation

The trace and maximum eigenvalue test are consistent that the series are co-integrated of order 1. This shows that there is a long run relationship between economic growth, electricity and investment in Zimbabwe over the reviewed period.

Granger Causality Tests

Given that there is cointegration, granger causality tests were done within the Vector Error Correction framework.

Table 4. VEC Granger Causality/Block Exogeneity Wald Tests

Dependent variable: GDP		
Null Hypothesis	**Prob.**	**Decision**
GDP does not Granger cause electricity consumption.	0.0085	Reject the Null
GDP does not Granger cause investment.	0.0625	Fail to reject the Null
Dependent variable: Electricity Consumption		
Electricity Consumption does not Granger cause GDP.	0.0025	Reject the Null
Electricity Consumption does not Granger cause investment.	0.0040	Reject the Null
Dependent variable: Investment		
Investment does not Granger cause GDP.	0.6449	Fail to reject the Null
Investment does not Granger cause electricity consumption.	0.0510	Fail to reject the Null

Source: Authors' computations

* Decision criteria is 5% level of significance

The results of granger causality test between electricity and economic growth shows that there is bi-directional causality. It means that in Zimbabwe, electricity causes economic growth and while on the other hand economic growth also causes economic growth. The results support strong feedback mechanism between electricity and economic growth.

Short and Long-term Elasticities

In order to elicit the short and long-term elasticities between electricity and economic growth, a single step error correction model was used. Table 7 shows the results of single step error correction model for the period 1980 to 2016.

Table 5. Results of Single Step Error Correction Model

Dependant Variable- GDP per Worker	
Variable	**Coefficient**
Lagged GDP per Worker	-0.149775*** (0.0012)
Lagged Electricity Consumption	0.105069** (0.03185)
Lagged Investment	0.055424*** (0.0115)
C	0.352170* (0.1527)
Δ Electricity Consumption	0.182846* (0.1119)

Δ Investment	0.044327*** (0.0340)
Diagnostics	
R-Squared	0.632337
DW- Statistic	1.9056495
Prob(F-Statistic)	0.000028

Source: Authors' Computations

The results suggest that in the long run, a 1% increase in electricity used in the economy increases economic growth by 0.7%, while a 1% increase in investment increases economic growth by 0.4%. In the short run, a 1% increase in electricity used, increases economic growth by 0.18%, while on the same note, 1% increase in investment drives economic growth by 0.04%.

6. Conclusion

The study using a multivariate framework for the period 1980 to 2016 shows that there is bi-directional causality between electricity and economic growth. The increase in electricity consumption results in an increase in economic growth, while a permanent increase in economic growth results in a permanent increase in electricity consumption. This finding supports the feedback hypothesis for Zimbabwe. The study also shows that in long run, a 1% increase in electricity consumption raises economic growth by 0.7% while investment growth raises output by 0.4%. This implies that the reduction in electricity consumption as a result of lower generation negatively affects economic growth. Thus, uninterrupted and sufficient electric power supply is an important determinant in stimulating economic growth in the economy. This implies that the huge shortage and outages in Zimbabwe experienced since the 2000, have placed a greater premium on economic growth in the economy.

The results call for government to implement policies aiming at increasing electricity generation in order to meet increasing electricity demand. In order to sustain high paced economic growth rates of around 7% as highlighted in the medium term economic blue print, the country should address the current electricity shortages. In this regard, the economy should urgently implement current earmarked electricity generation projects in order to support economic growth. Thus, the findings of the study emphasizes that electricity is a prerequisite and a binding constraint of achieving higher economic growth for Zimbabwe.

To sustainable growth in the long-term, the country should also plan ahead and build new power generating capacity to satisfy anticipated increasing demand for electricity as the economy grows. Government should invest on clean sources of

energy such as solar to ensure adequate energy to meet the needs of the agricultural, manufacturing and services sectors in the economy.

The study also finds that an increase in electricity consumption raises investment, which in turn to a larger extent underlies the increase in economic growth. Therefore, emphasis should be given on electricity generation and more investment. This means that in addition to addressing other cost of doing business indicators in the economy, government should ensure availability of electricity. Electricity is, therefore one of the critical determinants of investment in the economy. Government therefore needs to address electricity situation in order to attract investment. This is true given that most of the country's investments have been in the resource and extractive sectors which require massive electricity. Value addition of mineral resources also requires significant amounts of electricity.

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