AN EMPIRICAL ANALYSIS OF THE ENERGY CONSUMPTION – REAL GDP NEXUS FOR ZIMBABWE

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Abstract

This study looked into causality relationship between energy consumption and economic growth in Zimbabwe using time series data spanning from 1980 to 2011. Four views explaining the causality relationship between energy consumption and economic growth include the growth hypothesis, conservation hypothesis, feedback hypothesis and the neutrality hypothesis. Whilst the growth hypothesis argues that energy consumption promotes economic growth, conservation hypothesis says that it is in fact economic growth that drives energy consumption. The feedback hypothesis argues that both energy consumption and economic growth promote each other whilst according to the neutrality hypothesis, no causality relationship exist between the two variables either in the short or long run. Using the bi-variate causality test framework, this study failed to establish any direct causality relationship between energy consumption and economic growth. However, the results imply the existence of an indirect bi-directional causality relationship between the two variables. The study therefore recommends Zimbabwe authorities not only to scale up investment into energy generation capacity improvement infrastructure but also address indirect factors like employment, human capital development, financial market development, and government consumption, among others in order to boost sustainable economic growth.

Keywords: Zimbabwe, Energy Consumption, Economic Growth, Bi-variate Causality Test

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1. Introduction

Despite the fact that the causality relationship between energy consumption and economic growth is well grounded in the literature, empirical findings on the direction of causality between the two variables remains largely mixed, inconsistent, inconclusive and far from reaching consensus. Payne (2009) attributed the varying findings to differences in methodology, stage of economic development and type of energy used in the empirical analysis.

There are four dominant contradicting views regarding the causality relationship between energy consumption and economic growth (Odhiambo, 2009; Ewing et al, 2007; Ozturk, 2010 and Lee, 2006). These views are the growth hypothesis, conservation hypothesis, feedback hypothesis and the neutrality hypothesis. Proponents of the growth view argued that energy consumption stimulates economic growth whilst the conservation view proponents suggested that it is economic growth that spurs energy consumption needs of a country. The feedback view supporters established that both energy consumption and economic growth promote each other while the neutrality view proponents revealed non existence of any causality relationship between energy use and economic growth.

Similar studies on energy use and economic growth that focused on developed and other sub-Saharan African countries have largely been inconsistent, mixed and inconclusive (Odhiambo, 2010). Very few among these studies employed advanced econometric models such as the ARDL (Auto-Regressive Distributed Lag) approach (Odhiambo, 2010). Moreover, none of these empirical studies on sub-Saharan African countries focused on Zimbabwe despite the fact that the country provides a fertile ground to investigate the economic growth impact of energy rationing implemented from 2000 up to date. The current study focuses on filling that gap by investigating the causality relationship between energy use and economic growth in Zimbabwe using the bi-variate causality test framework. The study investigates the extent of Zimbabwe's exposure to external energy shocks since the country is currently a net energy importer. The results from the current research will help formulate energy policies that guarantee sustainable and long term economic growth in Zimbabwe.

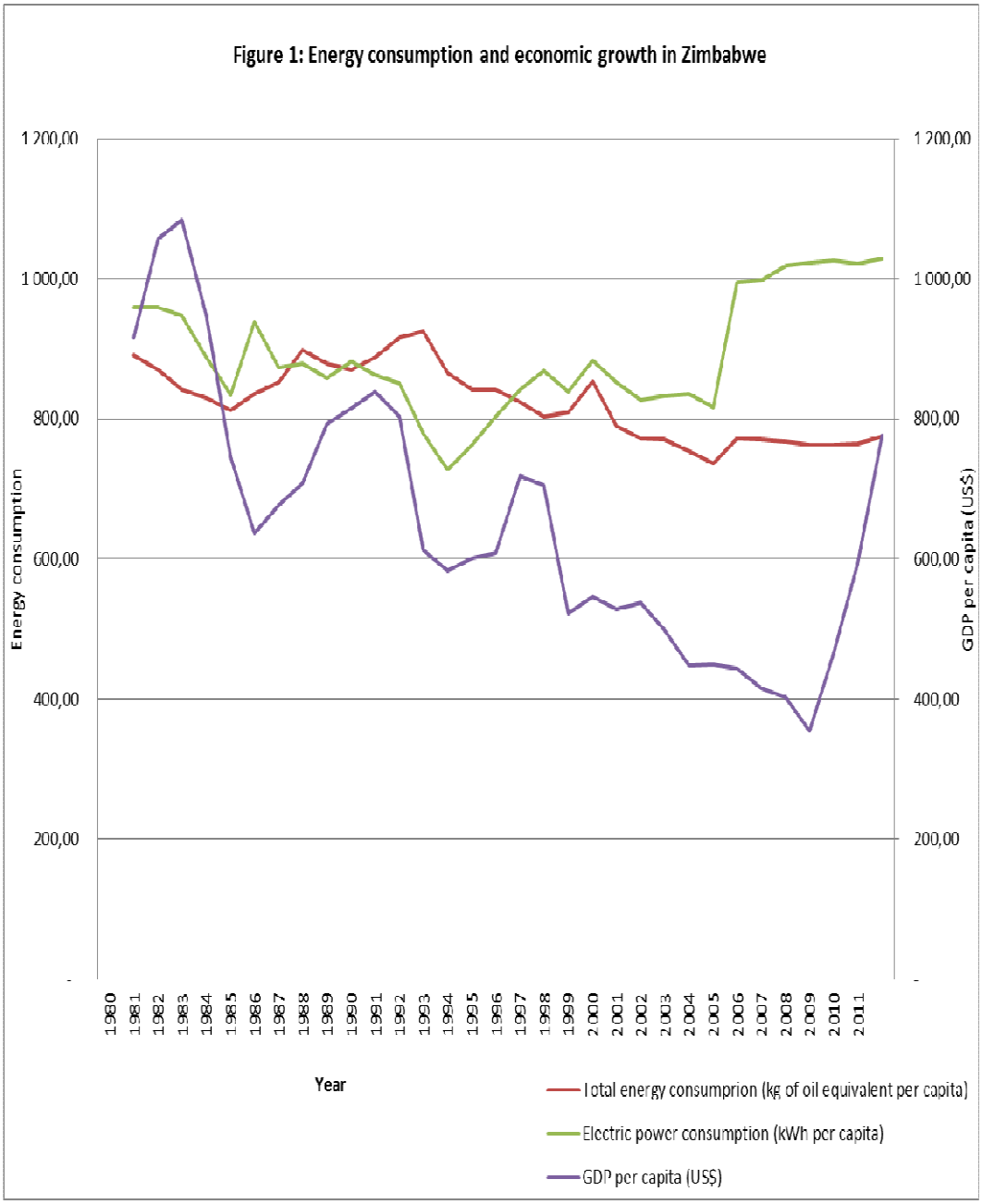
Total energy consumption (kg of oil equivalent per capita) was used as a proxy of energy consumption whilst GDP per capita was used as a proxy for economic growth. The rest of this study is structured as follows. Part 2 discusses energy consumption and economic growth trends in

Zimbabwe whilst part 3 provides an in depth overview of theoretical and empirical literature review. Data and econometric techniques is dealt with in part 4 whilst part 5 concludes the study.

2. Energy consumption and Economic Growth Trends in Zimbabwe

There has been a general decline in both electric power consumption (kWh/capita) and total energy consumption (kg of oil equivalent per capita) in Zimbabwe during the period from 1980 to 2010 (see Figure 1).

Figure 1. Energy consumption and economic growth in Zimbabwe



Source: World Development Indicators (2011)

According to World Bank (2011), total energy consumption went down by 6.1%, from 890 kg of oil equivalent per capita in 1980 to 836.3 kg of oil equivalent per capita in 1985 whilst electric power consumption (kWh/per capita) also decreased by 2.23% during the same period. Electric power consumption (kWh/per capita plummeted by a further 8.1%, from 938 kWh/per capita in 1985 down to

862.3 kWh/per capita in 1990. The period from 1985 to 1990 also was characterized by an increase in total energy consumption from 836 kg of oil equivalent per capita to 888 kg of oil equivalent per capita, representing a surge of 6.2%. Both electric power (kWh/per capita) and total energy consumption (kg of oil equivalent per capita) went down by 6.8% and 5.2% respectively during the period between 1990 and 1995.

The five-year periods from 1995 to 2010 saw total energy consumption decreasing and a steady increase in electric power consumption in Zimbabwe. Total energy consumption went down by 6.2% between 1995 and 2000 before experiencing another decline by a further 2.3%, from 790.3 kg of oil equivalent per capita in 2000 to 771.9 kg of oil equivalent per capita in 2005. Electric power consumption went up by 6.1% between 1995 and 2000 before experiencing a significant increase of 16.6% during the period 2000 to 2005. Total energy consumption in Zimbabwe recorded a paltry 1.02% decline during the period from 2005 to 2010. During the same period, electric power consumption went up by 2.8%, from 994.7 kWh/per capita in 2005 to 1022.2 kWh/per capita in 2010. However, the year 2011 was characterized by a marginal increase in both electric power and total energy consumption. Electric power consumption went up by 0.7% in 2011 whilst total energy consumption increased by 1.5%, from 764.01 kg of oil equivalent per capita in 2010 to 775.23 kg of oil equivalent per capita in 2011.

The first five year post independence period saw GDP per capita in Zimbabwe plummeting from US$916.24 billion in 1980 down to US$636.6 billion in 1985 (World Bank, 2011). This represented a 30.5% decline in GDP per capita. GDP per capita then grew by 31.8% during the period 1985 to 1990 (World Bank, 2011). The five year periods between 1990 and 2005 experienced a downfall in GDP per capita. The subsequent five year period saw GDP per capita plummeting by 27.5%, from US$839.01 in 1990 to US$608.6 in 1995. In real GDP terms, the Zimbabwe economy also declined from US$8.7 billion to US$7.1 billion during the same period. GDP per capita decreased by 13.2%, from US$608.6 in 1995 to US$528.12 in 2000 as the economic challenges persisted in Zimbabwe. GDP per capita further declined by 15.9%, from US$528 in 2000 to US$444 in 2005. Zimbabwe's GDP per capita plummeted by an average of 47.1% between 1990 and 2005. The period between 2005 and 2010 saw the Zimbabwe economy significantly improving as shown by GDP per capita going up by 33.9%. GDP per capita further went up by 30.6%, from US$594.5 in 2010 to US$776.2 in 2011 as the economy of Zimbabwe continue on the rebound.

3. Literature Review

There are four dominant and contradicting perspectives that exist in the literature explaining the relationship between energy consumption and economic growth (see Odhiambo, 2009). The first perspective is known as the growth hypothesis which argues that energy consumption spurs economic growth. The second perspective is the conservation hypothesis which says that economic growth drives energy consumption. The third perspective known as the feedback hypothesis maintains that both energy consumption and economic growth promotes each other whilst the fourth perspective called the neutrality hypothesis argues that there is no causality relationship at all between energy consumption and economic growth.

Previous research whose findings resonate with the growth hypothesis include those undertaken by Odhiambo (2009), Odhiambo (2010), Bowden and Payne (2009), Yuan (2008), Apergis and Payne (2009), Chiou-Wei et al (2008), Yoo and Jung (2005), Tsani (2010), Chontanawat et al (2008), Wei and Gang (2012), Yildirim and Aslan (2012), Okafor (2012), amongst others. Odhiambo (2009) established a uni-directional causality relationship running from total energy consumption to economic growth both in the short and long run in Tanzania. The same study showed that electricity consumption positively influenced economic growth in the short run only. In a separate study, Odhiambo (2010) discovered a uni-directional causal flow in both the short and long run running from energy consumption to economic growth in Kenya and South Africa. Bowden and Payne (2009) also found out results that concur with the growth hypothesis in the United States of America (USA) both in the short and long run whilst according to Yuan (2008), electricity consumption Granger caused economic growth in China in the short run only.

Apergis and Payne (2009) supported the growth hypothesis as their study revealed that energy consumption Granger caused economic growth in Central America during the period 1980 to 2004 both in the short and long run. The research by Chiou-Wei et al (2008) not only agreed with Apergis and Payne (2009) but resonated with the growth hypothesis. Energy consumption positively impacted on economic growth for Taiwan, Hong Kong, Malaysia and Indonesia both in the short and long run, revealed Chiou-Wei et al (2008). A study by Yoo and Jung (2005) for in Korea between 1977 to 2002 discovered results that are consistent with the growth hypothesis. Specifically, Yoo and Jung (2005) established that nuclear energy consumption Granger caused economic growth in Korea without any feedback effect in the long run.

Using aggregated energy consumption data, Tsani (2010) discovered a uni-directional causality relationship running from energy consumption to real

GDP in Greece both in the short and long run. The empirical findings from a study by Lee (2005) on 18 developing countries concurred with those of Tsani (2010). Chontanawat et al (2008) discovered that increasing energy consumption caused greater positive impact on GDP of developed as compared to developing countries. Their study specifically revealed that causality relationship running from energy consumption to economic growth more characterized developed OECD countries in comparison to developing non-OECD countries.

Using autoregressive distributed lag (ARDL) bounds test, Akinlo (2008) revealed that energy consumption positively influenced economic growth in Ghana, Kenya, Senegal and Sudan in the long run whilst findings by Mahadevan and Adjaye (2007) supported the growth hypothesis in developing countries in the short run only. The positive impact which a slight increase in electricity consumption cause on economic growth is more pronounced in developed than in developing countries, further argued Mahadevan and Adjaye (2007). The findings by Wolde-Rufael (2010) supported the growth hypothesis in as far as the causality relationship between nuclear energy consumption and economic growth in India is concerned. Moreover, Wei and Gang (2012) discovered that the positive causality relationship running from energy consumption to economic growth is not just a simple one in China. Efficient energy consumption and continuous development of new energy sources enabled China to realize sustainable economic growth. In a study for the 17 highly developed OECD nations using the bootstrap-corrected causality test, Yildirim and Aslan (2012) discovered a uni-directional causality relationship running from energy consumption to real GDP in Japan. Okafor (2012) discovered results that concur with Yildirim and Aslan (2012) in the case of Nigeria both in the short and long run.

Studies whose findings agree with the conservation hypothesis include those undertaken by Odhiambo (2010), Lee and Chang (2007) , Li et al (2011), Lise and Montfort (2007), Yan et al (2008), Huang et al (2008), Chiou-Wei et al (2008), Mehrara (2007), Akinlo (2008), Bartleet and Gounder (2010), Yoo and Ku (2009), Hossein et al (2012), Yildirim and Aslan (2012), Okafor (2012) and Ahmad et al (2012), among others. A study by Odhiambo (2010) revealed that economic growth influenced energy consumption in Democratic Republic of Congo (DRC) both in the short and long run. The implementation of energy conservation policies in countries that are not entirely energy reliant such as DRC will have insignificant economic growth impact, argued Odhiambo (2010). Lee and Chang (2007) established a uni-directional causality relationship running from economic growth to energy consumption in developing countries, hence supporting the conservation hypothesis. Li et al (2011) discovered that a 1% increase in real GDP per capita increased energy consumption in China by approximately 0.5% in the long run. Yan et al (2008) also in a study in China revealed the existence of Granger causality relationship running from GDP to coal and oil energy consumption in the short run only. In a study in Turkey, Lise and Montfort (2007) found out energy consumption to have been Granger caused by economic growth in the long run.

Huang et al (2008) using panel data analysis found out that it is economic growth that positively led to an increase in energy consumption in middle income groups in all the 82 countries. On the contrary, the same study revealed that economic growth negatively influenced energy consumption in the high income group. Chiou-Wei et al (2008) also established energy consumption to have been Granger caused by economic growth in Philippines and Singapore both in the short and long run. Moreover, Mehrara (2007), using panel data analysis found out a very strong uni-directional causality relationship running from economic growth to energy consumption for the oil exporting countries. Energy price policies reforms failed to have any influence on economic growth among oil exporting countries, argued Mehrara (2007). A study by Akinlo (2008) discovered results that support the conservation hypothesis in Sudan and Zimbabwe. Yoo and Ku (2009) suggested that economic growth Granger caused nuclear energy consumption without any feedback in France and Pakistan whilst Bartleet and Gounder (2010) in a study on New Zealand found results that did not deviate from those of other conservation hypothesis proponents.

In a study of Oil and Petroleum Exporting Countries (OPEC), Hossein et al (2012) revealed a Granger causality relationship running from economic growth to energy consumption in the short run for Saudi Arabia, United Arab Emirates, Iraq, Qatar and Iran. The findings by Yildirim and Aslan (2012) concurred with those of Hossein et al (2012). Specifically, Yildirim and Aslan (2012) discovered a uni-directional causality relationship that runs from real GDP to energy consumption for Australia, Canada and Ireland. A study by Ahmad et al (2012) revealed a uni-directional causality relationship running from economic growth to energy consumption both in the short and long run in Pakistan whilst Okafor (2012) in a study on South Africa concurred with other proponents of the conservation hypothesis.

Studies whose findings concur with the feedback hypothesis include those undertaken by Odhiambo (2009b), Bowden and Payne (2009), Lee and Chang (2007), Tsani (2010), Erdal (2008), Akinlo (2008), Mahadevan and Adjaye (2007), Yoo and Ku (2009), Apergis and Payne (2010), Dagher and Yacoubian (2012), Apergis and Payne (2012), Yildirim and Aslan (2012), among others. A study by Odhiambo (2009b) revealed that electricity consumption and economic growth Granger caused each other in South

Africa in both the short and long run. According to Bowden and Payne (2009), both commercial and residential primary energy consumption and real GDP promoted each other in USA. Lee and Chang (2007) also found out a bidirectional causality relationship between energy consumption per capita and real GDP per capita in developed countries only. In a study by Tsani (2010) using disaggregated data from Greece for period 1960 to 2006, a bi-directional causality relationship between residential and industrial energy consumption to real GDP was revealed.

Energy consumption and real Gross National Product promoted each other in Turkey during period 1970 to 2006, argued Erdal (2008). This implies that economic growth positively influenced energy consumption and that energy consumption also directly impacted on economic growth in Turkey. Using Granger causality test based on vector error correction model (VECM), Akinlo (2008) found out that both energy consumption and economic growth promoted each in Gambia, Ghana and Senegal. Mahadevan and Adjaye (2007) also discovered a bi-directional causality relationship in the developed countries between energy consumption and economic growth both in the short and long run. Yoo and Ku (2009) revealed a reciprocal Granger causality relationship between nuclear energy consumption and economic growth in Switzerland. A panel study on sixteen countries by Apergis and Payne (2010) revealed findings on the relationship between nuclear energy consumption and economic growth that are consistent with the feedback hypothesis in the short run.

Dagher and Yacoubian (2012) discovered a strong evidence of a bi-directional relationship between energy consumption and economic growth in Lebanon in both the short and long run. The same study revealed that restricting energy consumption reduced economic growth in Lebanon whilst negative economic growth was discovered to have lowered the total amount of energy consumed in Lebanon. Using panel data analysis of 79 countries, Akkemik and Goksal (2012) revealed findings that were consistent with the feedback view in approximately seven-tenths of the countries. A multivariate panel data study involving 80 countries carried out by Apergis and Payne (2012) revealed that renewable energy consumption and economic growth influenced each other both in the short and long run. Studies by Yildirim and Aslan (2012) produced results that are consistent with the feedback view for Italy, New Zealand, Norway and Spain.

Previous research whose results are consistent with the neutrality hypothesis include those undertaken by Bowden and Payne (2009), Huang et al (2008), Tsani (2010), Akinlo (2008), Yoo and Ku (2009), Hossein et al (2012), Rufael (2012), amongst others. Bowden and Payne (2009) discovered no causality between transportation primary energy consumption and real GDP in the USA. Using panel data analysis, Huang et al (2008) revealed no causality relationship between energy consumption and economic growth in the low income groups for 82 countries. Using disaggregated data, a study by Tsani (2010) found no causality relationship at all between transport energy consumption and real GDP in Greece both in the short and long run. The results from a study carried out by Akinlo (2008) also found out no relationship between energy consumption and economic growth in Cameroon, Nigeria, and Togo. Research by Yoo and Ku (2009) failed to detect any kind of causality relationship between nuclear energy consumption and economic growth in Argentina and Germany. In the long run, Hossein et al (2012) found out that no Granger causality relationship existed for all the OPEC nations.

A study by Rufael (2012) using the vector autoregressive (VAR) model found no causality relationship at all between nuclear energy consumption and economic growth in Taiwan. The same study in a way suggested that nuclear energy consumption failed to stimulate economic growth. Zhang and Cheng (2009) argued that energy consumption does not have any effect on economic growth, thus contradicting the findings by Mahadevan and Adjaye (2007). In other words, Zhang and Cheng (2009) suggested that any energy conservation policy does not affect economic growth in both short and long run in China.

4. Data and Econometric Techniques

a) Data

Time series annual data spanning from 1980 to 2011 was used for the purposes of this study. Both real GDP per capita and total energy consumption data were extracted from the World Development Indicators. Real GDP per capita was used as a proxy for economic growth whilst total energy consumption (kg of oil equivalent per capita) was used as a proxy of energy consumption levels in Zimbabwe. At level, both real GDP per capita and energy consumption data was auto correlated but the auto correlation was dealt with at 1st difference.

b) Unit root tests

Energy consumption and GDP per capita data sets were tested for unit root in both levels (see Table 1) and first difference (see Table 2) using both the Augmented Dickey Fuller (ADF) and the Philips-Perron (PP) tests. The unit root testing procedure has to be done before any investigation about the significance and direction of causality relationships is performed.

Table 1. Stationarity Tests of Variables in Levels

Variable	ADF /PP Test Statistic - Intercept	Critical Values -Intercept	
Stationarity Tests of Variables on first Difference - Augmented Dickey-Fuller - Test			
Energyconsump	-1.407259	-3.6661*	-2.9627**
Gdppercapita	-3.127469	-3.6661*	-2.9627**
Stationarity Tests of Variables on first Difference – Phillips-Perron (PP) Test			
Energyconsump	-1.490343	-3.6576*	-2.9591**
Gdppercapita	-1.771635	-3.6576*	-2.9591**

Note:
1) * and ** denote 1% and 5% levels of significance, respectively.
2) * MacKinnon critical values for rejection of hypothesis of a unit root.
3) The truncation lag for the PP tests is based on Newey and West (1987) bandwidth.

Using both the ADF and PP tests at levels, both energy consumption and GDP per capita were found to be non-stationary. This is because both the ADF and PP test were greater in value than the critical values. The next step was then done, which is to test for the stationarity at first difference using both the ADF and PP tests (see Table 2).

Table 2. Stationarity Tests of Variables on first Difference

Variable	ADF /PP Test Statistic - Intercept	Critical Values -Intercept	
Stationarity Tests of Variables on first Difference - Augmented Dickey-Fuller - Test			
DEnergyconsump	-4.542199	-3.6752*	-2.9665**
DGdppercapita	-4.944358	-3.6852*	-2.9705**
Stationarity Tests of Variables on first Difference – Phillips-Perron (PP) Test			
DEnergyconsump	-10.33322	-3.6752*	-2.9665**
DGdppercapita	-5.952159	-3.6752*	-2.9665**

Note:
1) * and ** denote 1% and 5% levels of significance, respectively.
2) * MacKinnon critical values for rejection of hypothesis of a unit root.
3) The truncation lag for the PP tests is based on Newey and West (1987) bandwidth.

The results of the unit root tests shown in Table 2 show that energy consumption and GDP per capita data sets are stationary at first difference. This is because both ADF and PP test value were lower in value than the critical values.

c) Johansen Co-integration Testing Procedure

After removing the auto-correlation and ensuring stationarity in both real GDP per capita and energy consumption data, the next step was to test the existence of the significant relationship between the variables. This was done by employing the Johansen Co-integration Testing Procedure (see Table 3).

Table 3. Co-integration Test Results

Eigenvalue	Likelihood Ratio	5% Critical Value	1% Critical Value	Hypothesized No. of CE(s)
0.478373	28.06628	19.96	24.6	None **
0.271669	9.192997	9.24	12.97	At most 1

***** Denotes rejection of the hypothesis at the 1% and 5% levels.
L.R. test indicates 1 co-integrating equation at 5% level.

Due to fact that auto-correlation has already been dealt with by 1st differencing, the author assumed no deterministic trend and intercept (no trend) in the co-integrating equation for both variables. We reject the null hypothesis that there is no significant long run relationship since Eigen value is lower than the critical values. The results show that there is a significant bi-directional long run relationship between the variables.

d) Granger causality tests

After establishing the existence of a significant relationship between real GDP per capita and energy consumption, the next step was to determine the direction of causality between the two variables. This was done by performing Granger causality tests (see Table 4).

Table 4. Granger Causality Tests

Null Hypothesis:	Obs	F-Statistic	Probability
DGDPPERCAPITA does not Granger Cause DENERGYCONSUMP	29	0.04492	0.95615
DENERGYCONSUMP does not Granger Cause DGDPPERCAPITA		0.18847	0.82944

We fail to reject the null hypothesis because the p-values is greater than 0.05 and the F-statistic is less than 4. The results of this study are consistent with the neutrality hypothesis. The study reveal that GDP per capita does not Granger cause energy consumption and also energy consumption does not Granger cause GDP per capita. The finding contradicts the co-integration results (see Table 3). The contradiction makes it clear that energy consumption and GDP per capita indirectly promotes each other in Zimbabwe via other factors such as employment, human capital development, financial market development, and government consumption, among others as suggested by literature.

5. Conclusion

This study looked into causality relationship between energy consumption and economic growth in Zimbabwe using time series data spanning from 1980 to 2011. Four views explaining the causality relationship between energy consumption and economic growth include the growth hypothesis, conservation hypothesis, feedback hypothesis and the neutrality hypothesis. Whilst the growth hypothesis argues that energy consumption promotes economic growth, conservation hypothesis says that it is in fact economic growth that drives energy consumption. The feedback hypothesis argues that both energy consumption and economic growth promote each other whilst according to the neutrality hypothesis, no causality relationship exist between the two variables either in the short or long run. Using the bi-variate causality test framework, this study failed to establish any direct causality relationship between energy consumption and economic growth. However, the results imply the existence of an indirect bi-directional causality relationship between the two variables. The study therefore recommends Zimbabwe authorities not only to scale up investment into energy generation capacity improvement infrastructure but also address indirect factors like employment, human capital development, financial market development, and government consumption, among others in order to boost sustainable economic growth.

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