Assessment of the Effects of Electricity consumption on the Economy using Granger Causality: Zambian Case

Douglas KUNDA, Mumbi CHISIMBA
Mulungushi University, School of Science Engineering and Technology, P.O Box 80415, Kabwe, Zambia
Email: dkunda@mu.edu.zm* and chishimba.mumbi@gmail.com
Phone Number: +260965883588*

Electricity consumption in developing countries such as Zambia continues to grow as the economy grows. As a result, it is important to study how the rate of electricity consumption affects the economy of a country. For this study, the economic variables that were used are the Gross Domestic Product and the Consumer Price index. The results from this study are that there is a unidirectional relationship between electricity consumption and the consumer price index where the rate of electricity consumption Granger causes the consumer price index. The study also showed that there is no causal relationship between electricity and GDP and that there was no causal relationship between electricity consumption and the Consumer Price Index.

Keywords: *Electricity consumption; GDP; CPI; Granger Causality; Zambia*

1 Introduction

Interest and study in the topic of the relationship between electricity consumption and other fields such as economic growth and demographics is a well-studied field in economic literature [1]. This area of study has seen increased interest since the oil crisis in the 1970s and the energy crisis due to peak oil in the 2000s which put pressure on countries to conserve energy and find ways of efficiently using the electricity that is available [2]. This, however is not always the case in developing countries such as Zambia which need the extra energy usage in order to develop their economies [2]. As such, it is important to properly study the relationship between the rate of electricity consumption and the economy. Various studies on the casual relationship between electricity consumption and the economy have produced various results as shown in Table **5**. The country of Zambia has seen an increase in electricity production as shown in Fig.10.

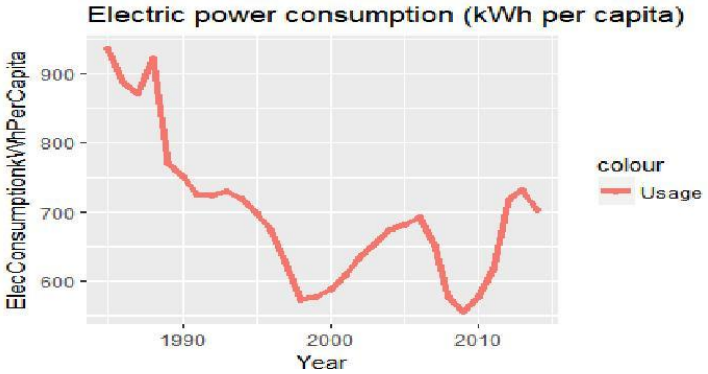

Fig.10. Electricity production in Zambia

Zambia has also seen an increase in electricity demand has led the national electricity supply company, ZESCO (Zambia Electricity Supply Corporation), to ration electricity through the practice of load shedding [3].

In order to best understand the relationship between electricity consumption or production and the economy, there is a need to understand the causal relationship between the two factors. There are three possible causal relationship categorizations namely (1) no causality, (2) unidirectional causality and (3) bi-directional causality between energy consumption and economic growth [1]. Unidirectional relationships can be further divided into two aspects namely (a) energy consumption causes economic growth and (b) economic growth causes energy consumption [1].

2. Theoretical background

The energy sector in Zambia is diverse in that the Zambian energy sector includes sources such as electricity, petroleum, coal, biomass, and renewable energy sources and from these sources, petroleum is the only one which is wholly imported in the country [4]. Also, as of 2014, there was a growth of demand of electricity and other forms of electricity for a rate of about 3% per annum mostly due to the increase in economic activity in the country. Overall, as of 2014, hydro-electricity is the most important energy source in the country after wood fuel which contributes about 10% of the national energy supply [4]. Though Zambia possesses about 40% of the water resources in the Southern African Development Community, Zambia has about 6,000 MW unexplored hydro power potential while only 2, 177 MW of power has been developed [4]. Fig.11 shows the installed generation capacity of electricity in Zambia.

No	Power Station	Installed Capacity	Type of Generation	Operator
1	Kafue Gorge	990	Hydro	ZESCO
2	Kariba North Bank	1,080	Hydro	
3	Victoria Falls	108	Hydro	
4	Lusemfwa and Mulungushi	56	Hydro	Lusemfwa Hydro Corp.
5	Small Hydros - combined	25	Hydro	ZESCO
6	Isolated Generation	8	Diesel	
7	Gas Turbine (stand by)	80	Diesel	Copperbelt Energy Corp.
	Total Installed Capacity	**2,177**		

Fig.11. Installed Generation Capacity in Zambia (Mega Watts) [4]

Aside from hydro-electricity, Zambia also makes relatively high use of petroleum products in Zambia. In total, petroleum contributed, as of 2014, an estimated 9% of the national energy requirements is imported and plays a crucial role in agriculture, transport and mining [4]. The petroleum is imported in the form of crude oil through the Tanzania-Zambia Mafuta oil pipeline and is refined at the Indeni oil refinery in Ndola city. Just like electricity, the demand for petroleum in Zambia has also increased in recent years. As of 2014, the demand for petroleum was at around 52 million litres per month. <FIGURE> shows the demand for petroleum products in Zambia as of 2014.

	Type of Petroleum Product	Average monthly consumption (liters)
1	Petrol Premium	12,000,000
2	Diesel / Gas Oil	30,000,000
3	Liquefied Petroleum Gas	190,000
4	JET-A-1	2,900,000
5	Heavy Fuel Oil	5,800,000
6	Kerosene	918,000
	TOTAL	**51,808,000**

Fig.12. Demand for Petroleum Products in Zambia [4]

Another source of energy in Zambia is that of bio-fuels. Though Zambia does not possess the capacity to produce bio-fuels, there are a number of areas where bio-fuels are used. Efforts such as production of bio-ethanol from molasses are being pursued though the though it is not being blended with petrol [4]. The Ministry of Energy and Water Development in Zambia estimated that an estimated 84 million litres of bio diesel and approximately 40 million litres of bio-ethanol are required by the country per annum as shown in Fig.13 and Fig.14.

Year	Diesel Sales Volume	5% Blend	10% Blend	15% Blend	20% Blend
Millions of Litres					
2008	379.10	18.96	37.91	56.87	75.82
2009	398.10	19.90	39.81	59.71	79.61
2010	417.96	20.90	41.80	62.69	83.59
2011	436.80	21.96	43.70	64.18	87.42
2012	452.18	22.90	45.80	65.90	90.21

Fig.13. Estimated Biodiesel Demand in Zambia (2008 to 2012) [4]

Year	Petro Sales Volume	10% Blend	15% Blend	20% Blend
Million Litres				
2006	176.15	17.62	26.42	35.23
2007	184.96	18.50	27.74	36.99
2008	194.21	19.42	29.13	38.84
2009	203.92	20.40	30.59	40.78
2010	203.92	21.41	32.12	42.82

Fig.14. Estimated Bio-ethanol Demand in Zambia (2006 to 2010) [4]

Table 5. Studies on the Relationship between Electricity and the economy

Study	Countries Studied	Variables Used	Method	Result
[2]	Pakistan	Electricity consumption and GDP	The augmented Dickey–Fuller (ADF) and Phillips–Perron (PP) tests	Using annual data for the period 1960–2008, the study finds the presence of unidirectional causality from real economic activity to electricity consumption
[5]	China, Hong Kong, Indonesia, India, Korea, Malaysia, the Philippines, Singapore, Taiwan and Thailand.	GDP and electricity consumption		Electricity conservation policies through both rationalizing the electricity supply efficiency improvement to avoid the wastage of electricity and managing demand side to reduce the electricity consumption without affecting the end-user benefits could be initiated without adverse effect on economic growth. The findings on the long-run relationship indicate that a sufficiently large supply of electricity can ensure that a higher level of economic growth.
[6]	Malaysia	Electricity generation, exports, prices and GDP	Cointegration, Granger causality	Electricity conservation policies, including efficiency improvement measures and demand management policies, which are designed to reduce the wastage of electricity and curtail generation can be implemented without having an adverse effect on Malaysia's economic growth.

[7]	Malawi	GDP and electricity consumption	Granger-causality (GC) and error correction (ECM)	bi-directional causality between kWh and GDP suggesting that kWh and GDP are jointly determined, but one-way causality running from NGDP to kWh.
[8]	China	Real GDP and electricity consumption	Granger causality	Real GDP and electricity consumption for China are cointegrated and there is unidirectional Granger causality running from electricity consumption to real GDP but not vice versa.
[1]	Bangladesh	GDP and electricity consumption	Cointegration and vector error correction model.	There is unidirectional causality from per capita GDP to per capita electricity consumption. However, the per capita electricity consumption does not cause per capita GDP in case of Bangladesh.
[9]	Australia, Austria, Belgium, Canada, Czech Rep, Denmark, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Italy, Japan, Korea, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Portugal, Slovak Rep., Spain, Sweden, Switzerland, Turkey, UK and USA	Electricity consumption–real GDP	Bootstrapped causality testing approach	Evidence in favour of electricity consumption causing real GDP in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK. The implication is that electricity conservation policies will negatively impact real GDP in these countries. However, for the rest of the 22 countries our findings suggest that electricity conversation policies will not affect real GDP.
[10]	Russia	Energy Consumption, electricity, and GDP	Granger Causality Test	Both the economic growth and electricity consumption empirically support each other and have a mutual and complementary relationship

A number of studies were performed in order to find out the causal relationship between electricity consumption/production and economic performance. For instance, in a study on Causality relationship between electricity consumption and GDP in Bangladesh [1], P. Mozumder and A. Marathe discovered that there was unidirectional causality from per capita GDP to per capita electricity consumption. However, P. Mozumder and A. Marathe noted that the per capita electricity consumption did not cause per capita GDP in case of Bangladesh. The result was similar to that discovered by F. Jamil and E. Ahmad, Using annual data for the period 1960–2008, which found the presence of unidirectional causality from real economic activity to electricity consumption [2]. Another study that was performed which could be better be related to Zambia is a study performed by C. B. Jumbe, in a study on the Cointegration and causality between electricity consumption and GDPin Malawi. The study showed that there was a bi-directional causality between kWh and GDP suggesting that kWh and GDP are jointly determined, but one-way causality running from NGDP to kWh [7]. In a study on Electricity consumption–real GDP causality nexus in 30 OECD countries, P. K. Narayan and A. Prasad dicovered that there was evidence in favour of electricity consumption causing a negatively impact on real GDP in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal, and the UK. However, findings from the rest of the 22 countries suggest

that electricity conversation policies will not affect real GDP [9].

On the electricity conservation front, S.-T. Chen, H.-I. Kuo and C.-C. Chen discovered that electricity conservation policies through both rationalizing the electricity supply efficiency improvement to avoid the wastage of electricity did not significantly affect economic growth [5].

3. Research Model and Hypothesis

3.1. Rate of Electricity Consumption

In electrical engineering, power consumption often refers to the electrical energy over time supplied to operate an electrical appliance.

The first set of hypotheses involve the relationship between Electricity consumption and the Gross Domestic Product at current prices in Billions of US dollars. The null hypothesis (H_0) in this case is that the rate of electricity consumption does not Granger cause the Gross Domestic Product (GDP) of the country. The first alternative hypothesis (H_1) is that the rate of electricity consumption does Granger cause the Gross Domestic Product (GDP) of the country.

H1 Rate of electricity consumption does Granger cause the Gross Domestic Product (GDP) of the country

H2 Rate of electricity consumption does Granger cause the Consumer Price Index

3.2 Gross Domestic Product

According to [11] GDP is one of the measures of national income and output for a given country's economy at a given period of time and adds that the definition of GDP is based on the total market value of all final goods and services produced within the country in a given period of time (normally one year).

The second set of hypotheses involve the relationship between Electricity consumption and the Gross Domestic Product at current prices in Billions of US dollars. The null hypothesis (H_0) in this case is that the Gross Domestic Product (GDP) does not Granger cause the rate of electricity consumption of the country. The first alternative hypothesis (H_1) is that the Gross Domestic Product (GDP) does Granger cause the rate of electricity consumption of the country.

H3 Gross Domestic Product (GDP) does Granger cause the rate of electricity consumption of the country

3.3. Consumer Price Index

The third set of hypotheses involve the relationship between electricity consumption and the Consumer Price Index (CPI). The null hypothesis (H_0) for this set of hypotheses is that the rate of electricity consumption does not Granger cause the Consumer Price Index. The first alternative hypothesis (H_1) is that the rate of electricity consumption does Granger cause the Consumer Price Index.

The final set of hypotheses involve the relationship between electricity consumption and the Consumer Price Index (CPI). The null hypothesis (H_0) for this set of hypotheses is that the Consumer Price Index does not Granger cause the rate of electricity consumption. The first alternative hypothesis (H_1) is that the Consumer Price Index does Granger cause the rate of electricity consumption

H4 Consumer Price Index does Granger cause the rate of electricity consumption

3.4 Methodology

For this study, Electric power consumption (kWh per capita) [12], the consumer price index [13] and the GDP (current US$) [14] in Zambia are used. The data analysed was obtained from the World Bank national accounts data, and OECD National Accounts data files and ranged from the year 1985 to the year 2014.

Fig.15, Fig 16 and Fig.17 shows graphs for the Electric power consumption (kWh per capita), the consumer price index per annum and the GDP (current US$) respectively.

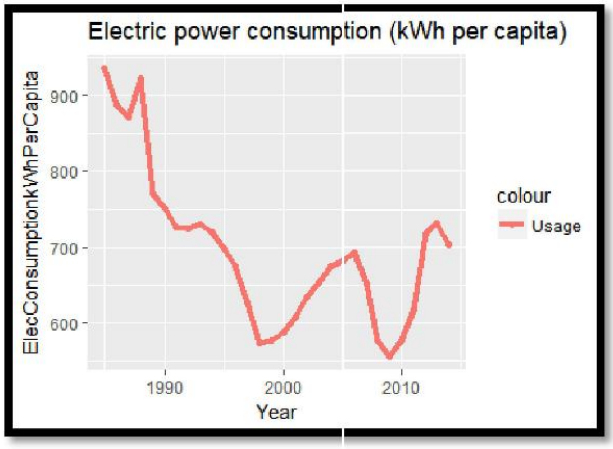

Fig.15. Electricity power consumption (kWh per capita)

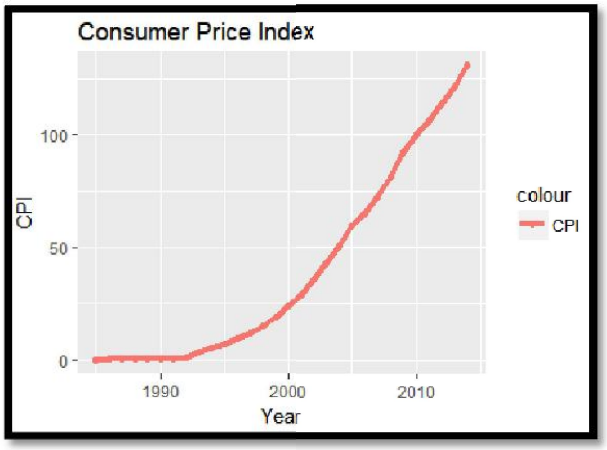

Fig 16. Consumer Price Index

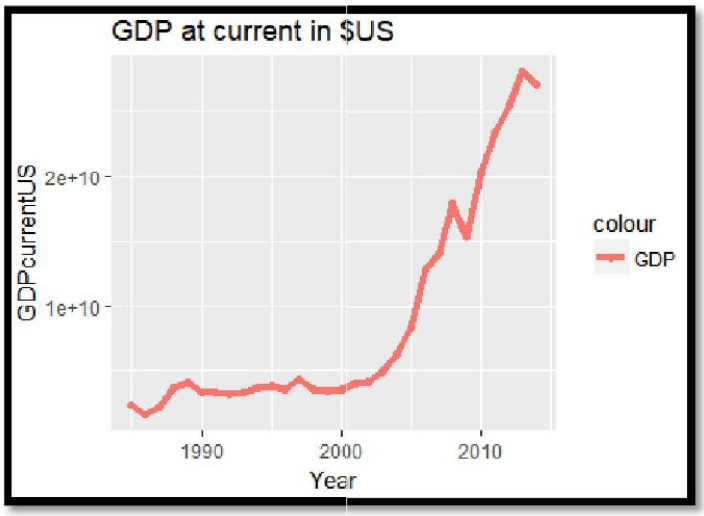

Fig.17.GDP at current in $US

For the data analysis, the Granger causality test to determine whether there is a causal relationship between (1) Electric power consumption (kWh per capita) [12] and the consumer price index, and (2) Electric power consumption (kWh per capita) [12] and the Gross Domestic Product (current US$) [14]. The first step taken in this study was to test the stationarity of all the variables using the Augmented Dickey-Fuller (ADF) test. Granger causality is under normal circumstances tested in the context of linear regression models. The formula for Granger causality is illustrated below:

$$\Delta X_{it} = \beta_{1i} + \sum_{j=1}^{k} \beta_{11ij} \Delta X_{i,t-j} + \sum_{j=1}^{k} \beta_{12ij} \Delta Y_{i,t-j} + \lambda_{1i} \varepsilon_{it-1} + \mu_{2it}$$

$$\Delta Y_{it} = \beta_{1i} + \sum_{j=1}^{k} \beta_{11ij} \Delta Y_{i,t-j} + \sum_{j=1}^{k} \beta_{12ij} \Delta X_{i,t-j} + \lambda_{2i} \varepsilon_{it-1} + \mu_{2it}$$

Fig.18. Granger causality formula **Error! Reference source not found.**

In the formulae above, for the data analysis, two data variables are compared using these formulae e.g. if Electricity consumption and GDP are the variables being compared, X would represent the Electricity consumption and Y would

represent the GDP. In this case, the first equation would measure changes in Electricity Consumption and Y would represent changes in the Gross Domestic Product. The Granger causality test is used in this paper the test methodology can be used for heterogeneous panel data models with fixed coefficient**Error! Reference source not found.**. The Granger causality test is also used to test the directionality of the cause I.e. we can find out whether Electricity Consumption Granger causes GDP of whether GDP Granger causes Electricity Consumption **Error! Reference source not found.**.

3.5 Data

The data used in this study was collected from the World Bank national accounts data, and OECD National Accounts data files for the Gross Domestic Product **Error! Reference source not found.**,The International Monetary Fund international financial statistics and data files**Error! Reference source not found.**, and the International Energy Agency data files on energy consumption**Error! Reference source not found.**. The selected range for the data is from the year 1985 to the year 2014. Fig.15. Electricity power consumption (kWh per capita), Fig 16. Consumer Price Index and Fig.17.GDP at current in $US illustrates the graphs for the electricity consumption from 1985 to 2014, the consumer price index from 1985 to 2014 and the Gross Domestic Product from 1985 to 2014 respectively. From Fig 16. Consumer Price Index, we note that electricity consumption has generally been declining since 1984 from just over 900KWh in the 1980s to somewhere below 600KWh just before 2010 and only saw a considerable rise between 2010 to 2014. The consumer price, on the other hand, has seen a general increase from 1985 to 2014 where it is noted to have increased from a rate from below 1 in 1985 to over 100 in post 2010. Finally, the Gross Domestic Product (GDP) has seen a steady increase from 1985 and saw a generally large increase from the mid 2000s to 2014. The data for electricity consumption however would, in the surface, seem to be paradoxical with that of population because under normal circumstances, because it may be assumed that electricity consumption increases with population.

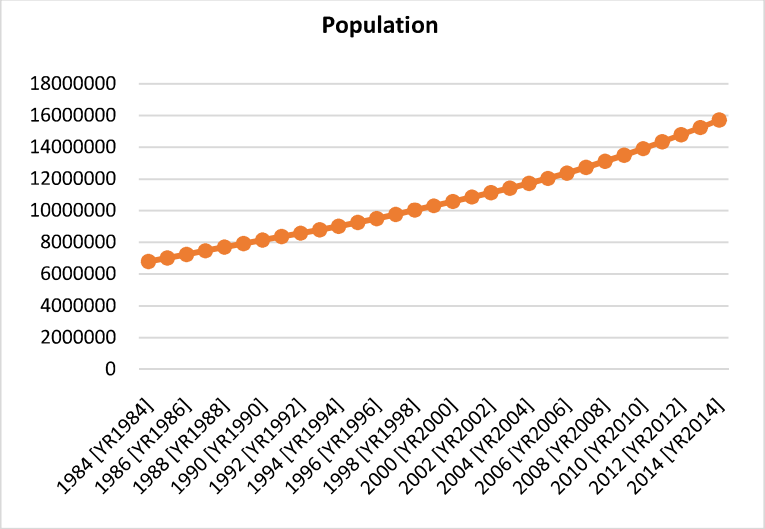

Fig.19. Population in Zambia

As seen from in Zambia, there is a general increase I population which may seem to be somewhat inverse to population growth however, there are other factors to consider such as the total population with access to electricity and other factors such as load shedding that have been conducted by the Zambia Electricity Supply Cooperation (ZESCO). The other variables on the other

hand seem to be positively related to one another.

The data analysis tool used is the R data analysis tool.

Table **5** shows the Descriptive statistics of included variables used in the study and Table 6, Table 7 and Table 8 shows the results of the Augmented Dickey-Fuller Test Unit Root Tests for the various variables.

Table 6: Augmented Dickey-Fuller Test Unit Root Test for consumer price index:

```
###############################################
#####
# Augmented Dickey-Fuller Test Unit Root Test #
###############################################
#####

Test regression drift


Call:
lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)


Residuals:
     Min       1Q   Median       3Q      Max
-3.4416 -0.6763  0.1192  0.7953  1.9492


Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  0.73658    0.42051   1.752   0.0921 .
z.lag.1      0.01465    0.01206   1.215   0.2359
z.diff.lag   0.77933    0.14454   5.392 1.36e-05 ***
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’
0.1 ‘ ’ 1

Residual standard error: 1.334 on 25 degrees of
freedom
Multiple R-squared:  0.8585,        Adjusted R-
squared:  0.8472
F-statistic: 75.84 on 2 and 25 DF,  p-value: 2.422e-
11


Value of test-statistic is: 1.2145 1.958


Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.58 -2.93 -2.60
phi1  7.06  4.86  3.94
```

Table 7. Augmented Dickey-Fuller Test Unit Root Test for Electricity consumption

```
###############################################
##
# Augmented Dickey-Fuller Test Unit Root Test #
```

```
###############################################
##

Test regression drift


Call:
lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)


Residuals:
     Min       1Q   Median       3Q      Max
-109.305  -14.166    5.051   16.191   93.854


Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept) 128.45752   58.23689   2.206   0.0368 *
z.lag.1      -0.19497    0.08407  -2.319   0.0289 *
z.diff.lag    0.17548    0.17659   0.994   0.3299
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' '
1

Residual standard error: 41.72 on 25 degrees of freedom
Multiple R-squared:  0.2043,    Adjusted R-squared:
0.1407
F-statistic:  3.21 on 2 and 25 DF,  p-value: 0.05742


Value of test-statistic is: -2.3191 2.911


Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.58 -2.93 -2.60
phi1  7.06  4.86  3.94
```

Table 8: Augmented Dickey-Fuller Test Unit Root Test for the gross domestic product at current

```
###############################################
#####
# Augmented Dickey-Fuller Test Unit Root Test #
###############################################
#####


Test regression drift


Call:
lm(formula = z.diff ~ z.lag.1 + 1 + z.diff.lag)


Residuals:
       Min         1Q     Median         3Q        Max
-3.694e+09 -7.471e+08 -1.067e+08  7.105e+08
```

```
3.795e+09

Coefficients:
             Estimate Std. Error t value Pr(>|t|)
(Intercept)  3.476e+08  4.647e+08   0.748    0.461
z.lag.1      9.178e-02  5.188e-02   1.769    0.089 .
z.diff.lag  -2.283e-01  2.432e-01  -0.939    0.357
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 1.653e+09 on 25 degrees of freedom
Multiple R-squared:  0.1128,    Adjusted R-squared:  0.04182
F-statistic: 1.589 on 2 and 25 DF,  p-value: 0.224

Value of test-statistic is: 1.7693 4.536

Critical values for test statistics:
      1pct  5pct 10pct
tau2 -3.58 -2.93 -2.60
phi1  7.06  4.86  3.94
```

Table 9: Descriptive statistics of included variables

Variable	Definition	Usable observations (1985-2014)	Range	Mean	Standard deviation	Minimum	Maximum
GDP	GDP at current in $US	30	29	8839092451	8420509841	1661948718	28045460442
CPI	Consumer Price Index	30	29	39.9	43.31508	0.01355	130.8
ELEC	Electric power consumption (kWh per capita)	30	29	695.2	102.7814	556.1	935.5

4. Results

As earlier stated, the Granger causality test was used in this study. The Granger causality test was performed in the R statistical package. For lag value of 1 was used in order to Granger test for all the hypotheses that were made. Table 10 shows the results for the for the Granger tests.

Table 10. Results of the Granger tests

Hypothesis	P-Value	Result
Rate of electricity consumption does not Granger cause the Gross Domestic Product (GDP)	0.5149	Cannot reject

Rate of electricity consumption does Granger cause the Gross Domestic Product (GDP) of the country	0.5149	Reject
Rate of electricity consumption does not Granger cause the Consumer Price Index	0.001077	Reject
Rate of electricity consumption does Granger cause the Consumer Price Index	0.001077	Cannot reject
Gross Domestic Product (GDP) does not Granger cause the rate of electricity consumption of the country	0.599	Cannot reject
Gross Domestic Product (GDP) does Granger cause the rate of electricity consumption of the country	0.599	Reject
Consumer Price Index does not Granger cause the rate of electricity consumption	0.4572	Cannot reject
Consumer Price Index does Granger cause the rate of electricity consumption	0.4572	Reject

The first set of hypotheses involve the relationship between Electricity consumption and the Gross Domestic Produce at current prices in Billions of US dollars. The null hypothesis (H_0) in this case is that the rate of electricity consumption does not Granger cause the Gross Domestic Product (GDP) of the country. For this set of hypotheses, we got a p-value of 0.5149 therefore, we cannot reject the null hypothesis. Therefore, because the p-value is not significant, we have to conclude that Electricity consumption does not Granger cause the GDP.

The second set of hypotheses involve the relationship between electricity consumption and the Consumer Price Index (CPI). The null hypothesis (H_0) for this set of hypotheses is that the rate of electricity consumption does not Granger cause the Consumer Price Index. The p-value for this set of hypotheses is 0.001077 therefore, we have to reject the null hypothesis. Therefore, because the p-value is significant, we have to conclude that the rate of electricity consumption does Granger cause the consumer price index.

The third set of hypotheses involve the relationship between Gross Domestic Produce at current prices in Billions of US dollars and the Electricity consumption. The null hypothesis (H_0) in this case is that the Gross Domestic Product (GDP) does not Granger cause the rate of electricity consumption of the country. The p-value for this set of hypotheses is 0.599 therefore, we cannot reject the null hypothesis. Therefore, because the p-value is not significant, we have to conclude that GDP does not Granger cause electricity consumption.

The final set of hypotheses involve the relationship between Consumer Price Index (CPI) and the electricity consumption. The null hypothesis (H_0) for this set of hypotheses is that the Consumer Price Index does not Granger cause the rate of electricity consumption. The p-value for this set of hypotheses is 0.4572 therefore, we cannot reject the null hypothesis. Therefore, because the p-value is not significant, we have to conclude that CPI does not Granger cause electricity consumption.

5. Conclusion

This paper examined the causal relationship between the rate of electricity consumption and the economy of a country using Gross Domestic Product and the Consumer Price Index in Zambia over the period of 1985 to 2014. The electricity consumption, Gross Domestic Product and Consumer Price Index were obtained from the World Bank on countries.

The results from this study are that there is a unidirectional relationship between electricity consumption and the consumer

price index where the rate of electricity consumption Granger causes the consumer price index. The study also showed that there is no causal relationship between electricity and GDP and that there was no causal relationship between electricity consumption and the Consumer Price Index.

These results imply that a lot of goods purchased by consumers in the country largely electrically dependant. Also, by virtue of the fact that electricity consumption does not impact GDP in any significant form, we can also imply that there is either GDP activities are not wholly dependant on electricity consumption of that there has been little development or regression in GDP activities which makes it largely unaffected by electricity consumption. From these observations, a recommendation can be made that there is a need for an improvement in the production levels of electricity since we have observed that lower electricity consumption caused a growth in the consumer price index. This would imply that should electricity supply, and consequently, consumption were to increase, more goods would be produced and as a result, with more goods on the market, there would be a lowering of the consumer price index. From this study, it is also recommended that the Zambian government provide incentives to encourage the manufacturing of goods and services such as tax exemptions for any enterprising companies and de-regulation to assist in making the business environment more conducive in the country.

One area where this study can be expanded upon is that the same techniques can be applied with other areas of the economic and social setup in Zambia and to try and identify what exactly causes the effect between electricity consumption and the social/economic factor. For instance, one possible area of expansion is to further delve into how dependant Zambia's economy is on electricity and also provide solutions on how Zambia can improve/industrialize its operations.

References

[1] P. Mozumder and A. Marathe, "Causality relationship between electricity consumption and GDP in Bangladesh," Energy Policy, vol. 35, pp. 395-402, 2006.

[2] F. Jamil and E. Ahmad, "The relationship between electricity consumption, electricity prices and GDP in Pakistan," Energy Policy, vol. 38, p. 6016–6025, 2010.

[3] R. o. Z. L. Shedding, "Engineering Institution of Zambia," September 2015. [Online]. Available: http://www.eiz.org.zm/wp-content/uploads/2015/10/151008_Report_On_ZESCO_Load_Shedding.pdf. [Accessed 5 May 2017].

[4] Z. D. Agency, "Energy Sector Profile," September 2014. [Online]. Available: http://www.zda.org.zm/?q=download/file/fid/55. [Accessed 8 May 2017].

[5] S.-T. Chen, H.-I. Kuo and C.-C. Chen, "The relationship between GDP and electricity consumption in 10 Asian countries," Energy Policy, vol. 35, pp. 2611-2621, 2007.

[6] H. H. Lean and R. Smyth, "Multivariate Granger causality between electricity generation, exports, prices and GDP in Malaysia," Energy, vol. 35, no. 9, pp. 3640-3648, 2010.

[7] C. B. Jumbe, "Cointegration and causality between electricity consumption and GDP: empirical evidence from Malawi," Energy Economics, vol. 26, p. 61–68, 2004.

[8] A. Shiu and P.-L. Lam, "Electricity consumption and economic growth in China," Energy Policy , vol. 32, p. 47–54, 2004 .

[9] P. K. Narayan and A. Prasad, "Electricity consumption–real GDP causality nexus: Evidence from a bootstrapped causality test for 30

OECD countries," Energy Policy, vol. 36, p. 910–918, 2008.

[10] Faisal, T. Tursoy and N. G. Resatoglu, "Energy Consumption, electricity, and GDP Causality; The Case of Russia, 1990-2011," Procedia Economics and Finance, vol. 39, p. 653 – 659, 2016.

[11] Z. M. Fathimath and A. Geetha, "Analysis of Data Mining Techniques and its Applications," International Journal of Computer Applications, vol. 140, no. 3, pp. 6-14, 2016.

[12] T. W. Bank, "Electric power consumption (kWh per capita)," The World Bank, 2017. [Online]. Available: http://data.worldbank.org/indicator/EG.USE.ELEC.KH.PC?locations=ZM. [Accessed 2017].

[13] T. W. Bank, "Consumer price index (2010 = 100) | Data," The World Bank, 2017. [Online]. Available: http://data.worldbank.org/indicator/FP.CPI.TOTL?locations=ZM. [Accessed 2017].

[14] T. W. Bank, "GDP (current US$) | Data," The World Bank, 2017. [Online]. Available: http://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=ZM. [Accessed 2017].