Energy Consumption and Economic Growth: Evidence from Low-Income Countries in Sub-Saharan Africa

Eyup DOGAN
The J. E. Walker Department of Economics, Clemson University, USA.
E-mail: edogan@clemson.edu

ABSTRACT: The main purpose of this paper is to investigate the causality relationship between energy consumption and economic growth in four low-income countries in Sub-Saharan Africa using the econometrics in time-series methods. Along the estimation process, I use the annual data on energy consumption and real GDP per capita over the years of 1971 and 2011. The results of the ADF unit root test show that the time series are not stationary for all countries at levels, but log of economic growth in Benin and Congo become stationary after taking the differences of the data, and log of energy consumption become stationary for all countries and LGR in Kenya and Zimbabwe are found to be stationary after taking the second differences of the time-series. The findings of the Johansen co-integration test demonstrate that the variables LEC and LGR are not co-integrated for the cases of Kenya and Zimbabwe, so no long-run relationship between the variables arises in any country. The Granger causality test indicates that there is a unidirectional causality running from energy use to economic growth in Kenya and no causality linkage between EC and GR in Benin, Congo and Zimbabwe.

Keywords: economic growth; energy consumption; causality test
JEL Classifications: C22; O43

1. Introduction

Should governments care about the relationship between energy consumption (EC) and economic growth (GR) in their home countries? It is important for policy makers to find out the causality relationship between EC and GR because the final result will help them to impose a proper energy policy. For instance, a government will pay more attention on a policy of stimulated energy use in the case where the reduction in EC will cause GR to go down as EC is found to have a positive impact on GR. Hence, the government will encourage people and firms to consume more energy in order to foster its growth since EC is also related to many factors such as unemployment, investment, savings and economic development. On the contrary, the government can carry out an energy conservation policy when there is no causality linkage between the variables or causality running from growth to energy use in that country. In such a case, if the government follows the appropriate policy it will unlikely face the severe economic turn down during the dramatic increase in energy prices.

Although a number of papers have focused on the causality relationship between energy consumption and economic growth over many countries from different continents, no clear consensus about this concern has been obtained. The differences in the estimation results mostly emerge due to the differences in countries’ conditions (i.e. economic developments, natural resources, consumption patterns, technology, and human capitals), applied econometrics techniques, and used time periods. Referring to the existing literature, there are typically four different outcomes related to the connection between EC and GR. These hypotheses are: “Conservation hypothesis” occurs when there is a one-way causality running from economic growth to energy consumption. “Growth hypothesis” exists if energy consumption causes economic growth, but GR does not cause EC. “Neutrality hypothesis” arises when there is no linkage between energy consumption and economic growth. “Feedback hypothesis” happens if there is a two-way causality between EC and GR (Ozturk, 2010).
In this paper, we plan to investigate the relationship between EC and GR in four low-income countries\(^1\) in Sub-Saharan Africa because of following reasons: 1) The published single and multi-country studies on the case of Sub-Saharan African countries have usually neglected the mentioned countries 2) The papers include Benin, Congo, Kenya and Zimbabwe have indicated different hypothesis in these countries 3) There has not been a recent multi-country study focuses on the low-income countries in Sub-Saharan Africa\(^2\). Thus, the purpose of this paper is to fulfill this gap and make an empirical contribution into the economic growth-energy literature. Because the linkage between the variables likely changes as the used time-period changes and the power of causality test increases as the number of observations in a time-series increases, the findings of this study will be more fresh and robust. In the frame of this paper, I apply econometrics in time-series methods: the Augmented Dickey-Fuller (ADF) unit root test, the Johansen co-integration test, vector autoregressive analysis (VAR), and the Granger causality test. I employ them to investigate whether or not the linkage between EC and GR exists over the period of 1971-2011.

The rest of paper is as follows: the second section brings literature review up, the third section gives more detail information about the data and methodology, the fourth section shows the empirical results, and the last section concludes the study.

2. Literature Review

There is a fair amount of empirical works that support each of the above-mentioned hypotheses. We hereby classify the existing literature as single country studies, multi-country studies, and panel studies. Empirical estimations on the causality interrelation between EC and GR on each group studies have mixed results that change from sample to sample and from time to time for the same sample.

2.1 Single Country Studies

2.1.1 Non-Sub Saharan African Countries

The pioneering work of the energy-economic growth literature by Kraft and Kraft (1978) exhibit a strong statistical relationship between EC and GR, and a unidirectional linkage from growth to energy use in the USA applying Sim’s Granger method over the period of 1947 through 1974. In addition to this early study, Yu and Hwang (1984) find no causality connection between EC and GR for the case of the USA from 1947-79. Cheng and Lai (1997) exhibit that there is a conservation hypothesis in Taiwan during the years 1954-93 using the Granger causality approach. Lee and Chang (2007) show that growth hypothesis exists if the amount of used energy is low and neutrality hypothesis arises if the level of energy consumption is high in a case study of Taiwan employing the threshold autoregressive (TAR) technique for the period of 1955 through 2003. Warr and Ayres (2010) perform the Engle-Granger method for the years 1946-2000, and find energy consumption to have a positive impact on economic growth in the USA. Lotfalipour et al. (2010) show the presence of conservation hypothesis in Iran during 1967-2007 applying Toda-Yamamoto method. Pao et al. (2011), and Pao and Tasai (2011) reveal that the causality runs from GR to EC in Russia and Brazil, respectively.

2.1.2 Sub Saharan African Countries


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\(^1\) These countries are Benin, Congo (Congo Dem. Rep), Kenya and Zimbabwe.

\(^2\) To the best of my knowledge, the recent study on the case of Sub-Saharan countries is published in 2010, and use the data from 1970-2007. Please see the literature review section for further knowledge on the published papers.
2.2 Multi-Country Studies

2.2.1 Non-Sub Saharan African Countries

The seminal work of Yu and Choi (1985) known as one of the earliest multiple-country studies expose energy-growth nexus in Philippines, neutrality hypothesis for the USA, UK and Poland, and growth-energy nexus in Korea running the Granger causality test. Masih and Masih (1996) support growth hypothesis in India and Indonesia, feedback hypothesis for Pakistan, and neutrality hypothesis for Malaysia, Singapore and Philippines applying the Johansen co-integration techniques, vector decomposition and Granger causality methods. Asafu-Adjaye (2000) applies co-integration and error correction methods and Granger causality test, and shows that energy-growth nexus arises in India and Indonesia, and feedback hypothesis happens in Philippines and Thailand. Soytas and Sari (2003) demonstrate the presence of growth hypothesis in Germany, France, Japan, Italy, Turkey and Korea, and the existence of feedback hypothesis in Argentina employing co-integration techniques and the Granger causality test. Keppler (2006) reveals conservation hypothesis in India and energy-growth nexus in China applying error correction model and the Granger causality test. Kalyoncu et al. (2013) examine the relationship between EC and GR in Georgia, Azerbaijan and Armenia using co-integration methods and causality test. They find that EC and GR are not co-integrated for Georgia and Azerbaijan but are co-integrated in the case of Armenia, and there is a one-way causality from GDP per capita to energy consumption per capita in Armenia.

2.2.2 Sub-Saharan African Countries


2.3 Panel Data Studies

2.3.1 Non-Sub Saharan African Countries


2.3.2 Sub-Saharan African Countries

Ozturk et al. (2010) examine the causality linkage between EC and GR in low income and high income regions from 1971-2005, and find the presences of conservation and feedback hypothesis for low income countries and high income countries, respectively. Eggoh et al. (2011) perform panel co-integration techniques and expose a bi-directional causality between EC and GR for 21 African countries over the years 1970-2006. Al-Mulali and Sub (2012) also support feedback hypothesis for 30 Sub-Saharan African countries applying panel co-integration method and panel VECM from 1980-2008. A recent study by Behmiri and Manso (2013) apply multivariate panel Granger causality method on oil exporting and oil importing Sub-Saharan African countries for the periods of 1985
through 2011, and show that energy-growth nexus occurs for oil exporting countries and feedback hypothesis arises in oil importing countries.

3. Data and Methodology
The data used in this study covers the period of 1971-2011 in 41 pairs of observations, and re follows:

a) As proxy for economic growth, the aggregate annual time series at constant prices for real GDP per capita. Aggregates are based on 2005 U.S. dollars, and converted from domestic currencies by using the annual exchange rates by the World Bank.
b) Energy consumption is defined as kg of oil equivalent per capita.

The relationship between economic growth and energy consumption in a country is stated as:

\[ GR_t = \pi_0 + \pi_1 \cdot EC_t + \zeta_t \]

and,

\[ EC_t = \delta_0 + \delta_1 \cdot GR_t + \eta_t \]

where the parameter \( \zeta \) and \( \eta \) are normally distributed error terms.

4. Empirical Results
4.1 Unit Root
The primary purpose of employing a unit root test is to pose whether or not the variables energy consumption and economic growth are stationary series. A time-series variable will be stationary if and only if it does not include a unit root at all. Granger and Newbold (1974) note that when both variables are non-stationary, an estimated regression will likely be spurious one which has high R\(^2\) (goodness of fit) and statistically significant coefficients on the independent variables, and the results are without any economic meaning.

I employ one of the most applied approaches, the ADF unit root test, to pose whether or not both series are stationary. Dickey and Fuller (1979) present the ADF unit root test as:

\[ \Delta X_t = \alpha + \beta X_{t-1} + \sum_{i=1}^{k} \lambda_i \Delta X_{t-i} - i + \gamma T + \epsilon_t \]  

where \( \epsilon_t \) is a normally distributed white noise error term, \( T \) is a deterministic time trend, \( X_{t-1} \) is the lagged value of the variable \( X_t \), \( \Delta X_{t-i} \) are the lagged values of the first differences of the variable \( X_t \), and \( \gamma, \lambda, \beta, \alpha \) are the estimated coefficients. In the frame of this study, the number of augmenting lag is determined by the method of Said and Dickey (1984), \( k = N^{1/3} \), where \( N \) is the number of observations in a time-series and \( k \) is the optimal lag length. A necessary step before moving on to the test process is to determine ‘\( k \)’ because of two reasons; (1) if ‘\( k \)’ is too small, some serial correlation can be left in the errors and the test result will be biased, (2) if ‘\( k \)’ is too large, power of the test will decrease. The appropriate lag length in the ADF test is approximately 4 for EC and GR as both of them have 41 pairs of observations.

The further step is to posit the right hypotheses and options for the estimation process of the ADF test. As commonly observed in the literature the logarithmic values of the variables are used in this paper, where LEC and LGR represent for log of EC and log of GR, in order. The null hypotheses with an option of trend in table 1 are that LEC and LGR in each single country have a unit root, and the alternative hypotheses are that neither has a unit root. Both the z-scores and p-values yield that LEC and LGR in every single country have a unit root because I fail to reject the null hypotheses at 5% level of significance.

If a time series is found to be non-stationary, one of the most followed methods will be taking the first difference of the variable in order to make it a stationary series. In addition, the second difference of the variable will be used if it does not become stationary after taking the first difference of the data. Thus, I first take the first differences of LEC and LGR in Benin, Congo, Kenya and Zimbabwe. The null hypotheses and the alternative hypotheses without an option of trend in table 2 are that each of the variables in every separated country has a unit root, and neither has a unit root, respectively.

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Table 1. ADF Unit Root Test at Levels

<table>
<thead>
<tr>
<th>Country</th>
<th>Variables</th>
<th>Test Statistic</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
<th>P-Value</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>EC</td>
<td>-0.28</td>
<td>-4.27</td>
<td>-3.55</td>
<td>-3.21</td>
<td>0.98</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>GR</td>
<td>-2.11</td>
<td>-4.27</td>
<td>-3.55</td>
<td>-3.21</td>
<td>0.53</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td>Congo</td>
<td>EC</td>
<td>-1.7</td>
<td>-4.27</td>
<td>-3.55</td>
<td>-3.21</td>
<td>0.74</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>GR</td>
<td>-1.62</td>
<td>-4.27</td>
<td>-3.55</td>
<td>-3.21</td>
<td>0.78</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td>Kenya</td>
<td>EC</td>
<td>-1.37</td>
<td>-4.27</td>
<td>-3.55</td>
<td>-3.21</td>
<td>0.86</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>GR</td>
<td>-2.28</td>
<td>-4.27</td>
<td>-3.55</td>
<td>-3.21</td>
<td>0.44</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>EC</td>
<td>-1.93</td>
<td>-4.27</td>
<td>-3.55</td>
<td>-3.21</td>
<td>0.63</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>GR</td>
<td>-1.41</td>
<td>-4.27</td>
<td>-3.55</td>
<td>-3.21</td>
<td>0.85</td>
<td>Fail to Reject</td>
</tr>
</tbody>
</table>

Table 2. ADF Unit Root Tests in Differences

<table>
<thead>
<tr>
<th>Country</th>
<th>Variables</th>
<th>Test Statistic</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
<th>P-Value</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>DLEC</td>
<td>-2.14</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.22</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>DLGR</td>
<td>-3.06</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.02</td>
<td>Reject</td>
</tr>
<tr>
<td>Congo</td>
<td>DLEC</td>
<td>-2.10</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.24</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>DLGR</td>
<td>-2.89</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.04</td>
<td>Reject</td>
</tr>
<tr>
<td>Kenya</td>
<td>DLEC</td>
<td>-2.69</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.07</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>DLGR</td>
<td>-2.19</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.20</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>DLEC</td>
<td>-2.76</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.06</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>DLGR</td>
<td>-2.22</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.19</td>
<td>Fail to Reject</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Country</th>
<th>Variables</th>
<th>Test Statistic</th>
<th>1% Critical Value</th>
<th>5% Critical Value</th>
<th>10% Critical Value</th>
<th>P-Value</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>DLEC</td>
<td>-3.54</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.006</td>
<td>Reject</td>
</tr>
<tr>
<td>Congo</td>
<td>DLEC</td>
<td>-3.68</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.004</td>
<td>Reject</td>
</tr>
<tr>
<td>Kenya</td>
<td>DLEC</td>
<td>-3.97</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.001</td>
<td>Reject</td>
</tr>
<tr>
<td></td>
<td>DLGR</td>
<td>-4.32</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.004</td>
<td>Reject</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>DLEC</td>
<td>-4.58</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.0001</td>
<td>Reject</td>
</tr>
<tr>
<td></td>
<td>DLGR</td>
<td>-3.25</td>
<td>-3.68</td>
<td>-2.97</td>
<td>-2.61</td>
<td>0.01</td>
<td>Reject</td>
</tr>
</tbody>
</table>

Because the ADF test statistic is smaller than 5% critical value, the null hypotheses of having a unit root can be rejected for the variable DLGR in Benin and Congo. Since the ADF test statistic is bigger than 5% critical value, I cannot reject that DLGR in Kenya and Zimbabwe, and DLEC in Benin, Congo, Kenya and Zimbabwe have a unit root.

The results in table 2 indicate that the variable LEC become stationary in all countries and the variable LGR are concluded to be stationary for Benin, Congo, Kenya, and Zimbabwe after taking the second differences of them. The outcomes of the ADF test also show that LEC and LGR have different order of integration for the countries Benin and Congo. For the case of Kenya and Zimbabwe LEC and LGR have the same order of integration and are integrated in order two, I(2). Two or more time-series can be co-integrated if they are integrated in the same order, and so the variables at levels did not cause a spurious regression. Thus, co-integration techniques are performed for the countries which have the same order of integration for LEC and LGR.
4.2 Co-integration Test

Co-integration implies that one or more linear combinations of the time-series variables are stationary even though they are individually non-stationary (Dickey et al., 1991). Before applying a co-integration test, I first should determine the optimal lag length using selection-order criteria such as LR and AIC. For the case of Kenya the appropriate lag length is two, and for the case of Zimbabwe the provided lag length is one. After determining the optimal lag length, the Johansen ML co-integration test presented by Johansen (1988, 1991) is applied to finalize whether or not LEC and LGR are co-integrated. This test takes the following vector auto-regression (VAR) model (2):

$$\Delta \ln Y_t = \beta + \sum_{i=1}^{k} \Gamma_i \Delta \ln Y_{t-i} + \Pi \ln Y_{t-i} + \epsilon_t$$

(2)

where $Y_t$ represents an $n*1$ vector of variables energy consumption and economic growth which are integrated in order two. The parameters $\Gamma$ and $\Pi$ represent for $n*n$ matrices of coefficients on the lagged variables, and $\epsilon_t$ is an $n*1$ vector of innovations. All I need to know is that if the rank is zero, there will be no co-integrating relationship. If the rank (r) is one there will be one co-integrating relation, if it is two there will be two and so on. When there is a co-integration between two time-series, these series will have a long-run relation and roughly follow the same patterns.

The Johansen ML co-integration test is based on the maximum likelihood estimation and two statistics: the maximum eigenvalue ($K_{max}$) and the trace-statistics ($\lambda_{trace}$), where the $\lambda_{trace}$ tests the null hypothesis that r is equal to zero (no co-integration) against a general alternative hypothesis of $r>0$. The $K_{max}$ tests the null hypothesis that the number of co-integrating vectors is r versus the alternative of $r+1$ co-integrating vectors. The results in table 3 indicate that the null hypotheses of no co-integrations versus one co-integrating equations for both countries cannot be rejected at 5% level of significance since trace statistics are smaller than 5% critical value and the stars also prove the conclusion. I finally deduce that the variables LEC and LGR in Kenya and Zimbabwe are not co-integrated, nor do they have long-run relationships.

### Table 3: The results of the Johansen ML Co-integration test

<table>
<thead>
<tr>
<th>Maximum Rank</th>
<th>parms</th>
<th>LL</th>
<th>eigenvalue</th>
<th>trace statistic</th>
<th>5% critical value</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Kenya</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>6</td>
<td>214.70</td>
<td>-</td>
<td>7.47*</td>
<td>15.41</td>
</tr>
<tr>
<td>1</td>
<td>9</td>
<td>217.45</td>
<td>0.13</td>
<td>1.98</td>
<td>3.76</td>
</tr>
<tr>
<td>2</td>
<td>10</td>
<td>218.44</td>
<td>0.04</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>b) Zimbabwe</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>0</td>
<td>2</td>
<td>134.49</td>
<td>-</td>
<td>4.93*</td>
<td>15.41</td>
</tr>
<tr>
<td>1</td>
<td>5</td>
<td>136.91</td>
<td>0.11</td>
<td>0.10</td>
<td>3.76</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>136.96</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

4.3. Granger Causality

Granger (1988) notes that the Granger causality test is a statistical hypothesis test to determine whether or not one time series is useful in forecasting another. In addition, Park and Phillips (1989), and Sims et al. (1990) show that causality results can be spurious if non-stationary time series data are used in the process of test. Hence, I should carefully establish the properties of time series involved before applying the Granger causality test. When one of the series is found to be integrated in order one and the other series is I(2), VAR is specified in term of first difference for I(1) and in term of second difference for I(2). If both series are concluded to be I(2) but not co-integrated, then the appropriate model will be VAR in the second differences of the data.

The null hypothesis of the Granger causality test is formally designed as that a variable X does not Granger cause another variable Y. In this study, there are two null hypotheses: Energy consumption does not Granger cause economic growth, and economic growth does not Granger cause energy consumption.
Table 4. The Results of the Granger Causality Test

<table>
<thead>
<tr>
<th>Country</th>
<th>Null Hypothesis</th>
<th>Chi2</th>
<th>Lag</th>
<th>Prob.</th>
<th>Decision</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benin</td>
<td>EC does not Granger cause GR</td>
<td>0.21</td>
<td>1</td>
<td>0.64</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>GR does not Granger cause EC</td>
<td>0.11</td>
<td>1</td>
<td>0.73</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td>Congo</td>
<td>EC does not Granger cause GR</td>
<td>0.04</td>
<td>1</td>
<td>0.82</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>GR does not Granger cause EC</td>
<td>0.001</td>
<td>1</td>
<td>0.99</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td>Kenya</td>
<td>EC does not Granger cause GR</td>
<td>4.91</td>
<td>1</td>
<td>0.02</td>
<td>Reject</td>
</tr>
<tr>
<td></td>
<td>GR does not Granger cause EC</td>
<td>0.95</td>
<td>1</td>
<td>0.32</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>EC does not Granger cause GR</td>
<td>3.68</td>
<td>4</td>
<td>0.45</td>
<td>Fail to Reject</td>
</tr>
<tr>
<td></td>
<td>GR does not Granger cause EC</td>
<td>5.97</td>
<td>4</td>
<td>0.2</td>
<td>Fail to Reject</td>
</tr>
</tbody>
</table>

In table 4, the results of the Granger causality test between EC and GR for each country are reported. The maximum lag lengths are selected using the AIC information criteria. The probability values for chi2 statistics are given in table 4. If these probability values are higher than 0.05, the hypothesis of EC does not Granger cause GR (or GR does not Granger cause EC) cannot be rejected at 5% confidence level. Referring to that inference, I find that energy consumption Granger causes economic growth in Kenya, whereas EC does affect the pattern of GR in Benin, Congo and Zimbabwe. In addition, I also find that economic growth does not Granger cause energy consumption in any country. In other words, this paper shows the presence of growth hypothesis in Kenya, and neutrality hypothesis for the cases of Benin, Congo and Zimbabwe.

5. Conclusion

It is quite crucial for governments to know the existence and direction (if any) of the causality relationship between EC and GR in their own lands because having the knowledge of the direction of the linkage will assist policy makers to implement an appropriate energy policy. As an example, a policy maker will impose a strategy that increases energy consumption to promote economic growth if there is energy-growth nexus arises in that country, and will follow a plan which helps the government conserve energy stock if neutrality hypothesis occurs in that country. In the case of growth and feedback hypotheses, the government can contribute to economic growth and in the case of neutrality and conservation hypotheses, the government can protect its economy against a huge increase in energy prices and safeguard the environment through imposing a proper policy.

This study aims to analyze the causality relationship between energy consumption and economic growth in four Sub-Saharan African countries using annual data on EC and GR from 1091-2011 because the old studies have usually dismissed the low-income Sub-Saharan African countries Benin, Congo, Kenya and Zimbabwe and there has not been a recent study investigating the linkage between the variables for these countries. To do so, I apply econometrics in time-series methods: the Augmented Dickey-Fuller (ADF) unit root test, the Johansen co-integration test, vector autoregressive analysis (VAR), and the Granger causality test.

The results of the ADF unit root test show that the time series are not stationary for all countries at levels, but log of economic growth in Benin and Congo become stationary after taking the differences of the data, and log of energy consumption become stationary for all countries and LGR in Kenya and Zimbabwe are found to be stationary after taking the second differences of the time-series. The findings of the Johansen co-integration test demonstrate that the variables LEC and LGR are not co-integrated for the cases of Kenya and Zimbabwe, so no long-run relationship between the variables arises in any country. The Granger causality test indicates that there is a unidirectional causality running from energy use to economic growth in Kenya and no causality linkage between EC and GR in Benin, Congo and Zimbabwe. As I find the existence of growth hypothesis in Kenya, policy makers in there should consume more energy to have increased economic growth; however, the governments in Benin, Congo and Zimbabwe should implement a conservation policy to avoid unnecessary energy consumption.
References


