Energy Consumption and Economic Growth Modelling in SADC Countries: An Application of the VAR Granger Causality

Sunde, Tafirenyika

Namibia University of Science and Technology

26 August 2017

Energy Consumption and Economic Growth Modelling in SADC Countries: An Application of the VAR Granger Causality Analysis

Tafirenyika Sunde

ABSTRACT

The study investigated the relationship between energy consumption and economic growth in 10 SADC countries using the VAR model over the period 1971 to 2015. The variables used were first converted to growth rates before they were used in the model estimated. The results indicate unidirectional causality running from real economic growth to energy consumption in Angola, Democratic Republic of Congo, Mauritius, Namibia, bidirectional causality between energy consumption and economic growth in Botswana and Mauritius and no causality in Mozambique, South Africa, Zambia and Zimbabwe. In countries where real economic growth Granger causes energy consumption the conservation hypothesis is confirmed. In countries where no causality was found the neutrality hypothesis is confirmed which implies that energy conservation will not lead to decreased economic growth and energy consumption will not be stimulated by economic growth. The feedback hypothesis confirmed in Botswana and Mauritius implies that an increase in the economic output will increase the level of energy consumption while an energy conservation policy will adversely affect economic output.

Keywords: Economic growth; energy consumption; VAR model; Granger causality; SADC countries.

JEL Classifications: C33; O4; O13; Q43

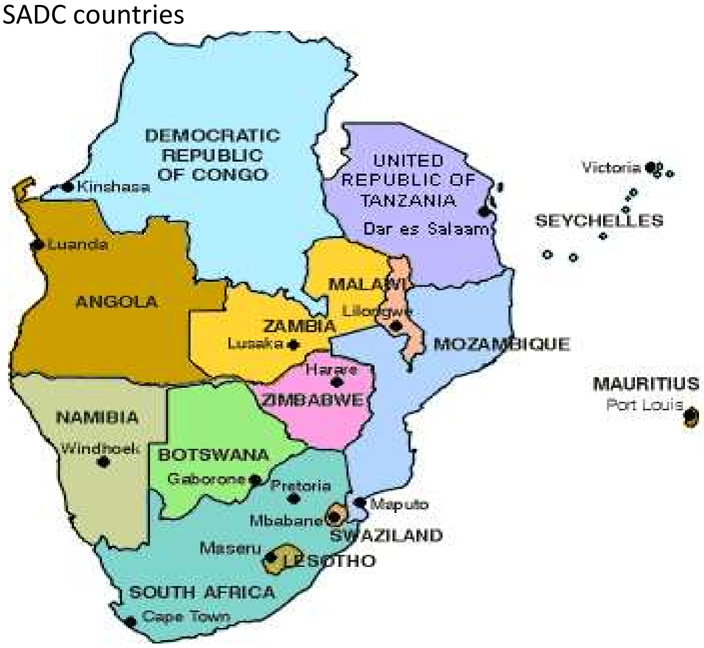
1. Introduction

The economic growth and energy consumption nexus was previously investigated by numerous research studies. From these previous research studies, four hypotheses regarding this nexus can be found in the empirical literature that dealt with this topic. These include the conservation hypothesis, the growth hypothesis, the neutrality hypothesis and the feedback hypothesis. In the first place, the conservation hypothesis claims that the changes in energy consumption originate from the changes in the level of economic activity. Secondly, the growth hypothesis is based on unidirectional causality running from energy consumption to economic growth. Further, the growth hypothesis assumes that there are countries where the increase of energy consumption is a significant component of economic development. Next, the feedback hypothesis assumes that there are countries with bi-directional causal relationships between economic growth and energy consumption. Finally, the neutrality hypothesis states that there are countries in which energy consumption does not depend on economic growth and vice versa. In this article, the author investigates the nexus between energy consumption and economic growth in 10 Southern Africa Development community (SADC) countries. The author applied the Granger's causality analysis, which allows for the investigation of the existence and direction of influence between energy consumption and economic growth. The article makes a significant contribution to existing literature because the investigation focuses on SADC countries, which as far as the author knows, have rarely been studied collectively by the previous studies. In addition, these countries have not been studied collectively using the methodology that is used in this study.

2. SADC Energy consumption and economic growth trends

One cannot discuss about the relationship between energy consumption and economic growth in the SADC without reference to the trend diagrams that relate to these variables. The current study is going to study Angola, Botswana, Democratic Republic of Congo, Mauritius, Mozambique, Namibia, South Africa, Tanzania, Zambia and Zimbabwe. It should be noted that the choice of these countries was mainly dictated by the availability of data. Figure 1 shows the map of all the SADC countries, including those analysed in this study. The study uses Y to denote GDP and E to denote electricity consumption.

Figure 1: Map of the SADC countries



Source: World Wide Web

Figure 2 shows the trends in energy consumption in SADC countries. The trend diagram for South Africa shows that energy consumption increased from 1970 up to 1996 after which it appears to stabilise and become constant. The trends for Angola, Botswana, Mauritius, Mozambique, Namibia, and Tanzania are upward for the periods for which data are available in these countries. Mozambique had exponential growth in electricity consumption after 1996, and this may be due to the cessation of the civil war in 1992. Zambia, DRC, and Zimbabwe have trends that slightly decrease over time. In the case of Zambia and Zimbabwe, such trends are attributable to the economic crises these economies encountered in the 1990s and 2000s, respectively. In the case of the DRC, its trend is attributable to the political instability the country has experienced over the years. Angola's electricity consumption slightly declined between 1984 and 1996 after which it commenced to rise significantly. The author can, therefore, conclude that electricity consumption for the entire region has been on an upward trend even though some countries experienced declines during the period under study.

Figure 3 shows the trend diagram of GDP for the SADC countries. The trend diagrams are upward sloping save for those for Zimbabwe and DRC for the reasons explained earlier. The trend for the DRC falls from 1970 to reach a minimum in the year 2000 after which it commences to rise. GDP for Zimbabwe was on an upward trajectory since 1960 up to the year 2000. It declined from the year 2000 to reach a minimum in 2008 after which it commenced to rise modestly again. The period after 2000 is mainly associated with the land redistribution to the black masses in Zimbabwe. The author can conclude here that the GDP for SADC increased during the period under study, albeit moderately.

Figure 2: Trend diagrams for energy consumption

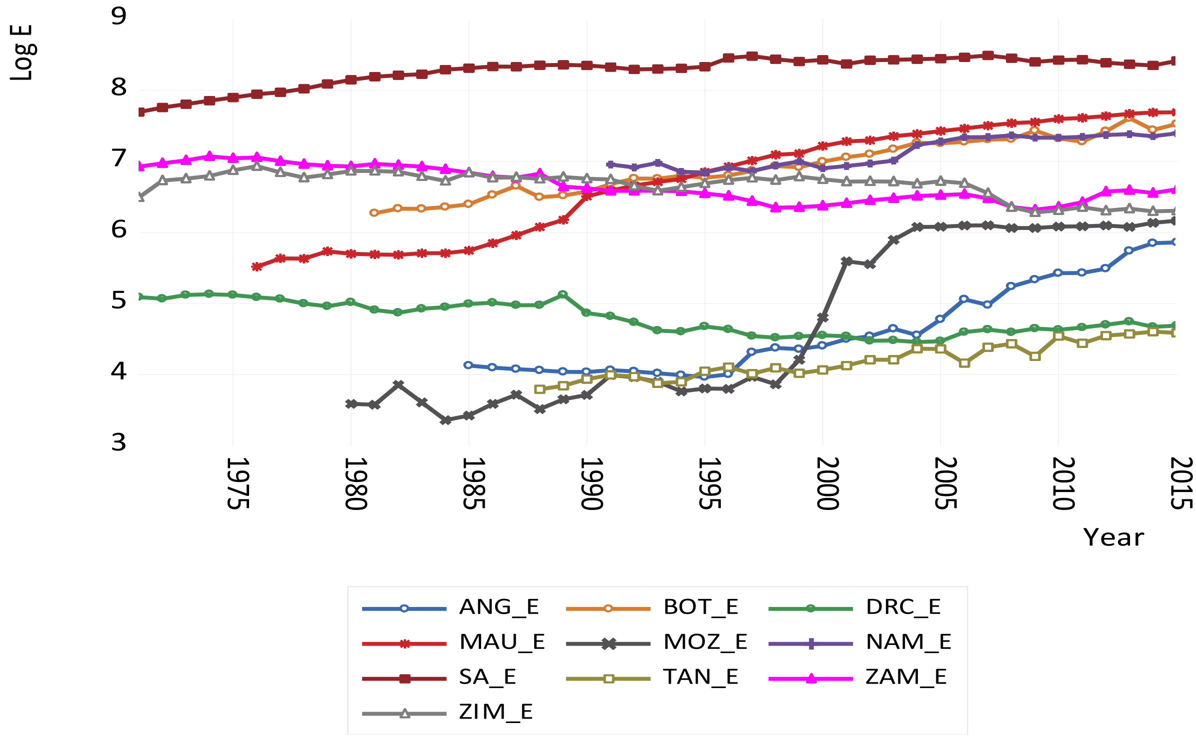
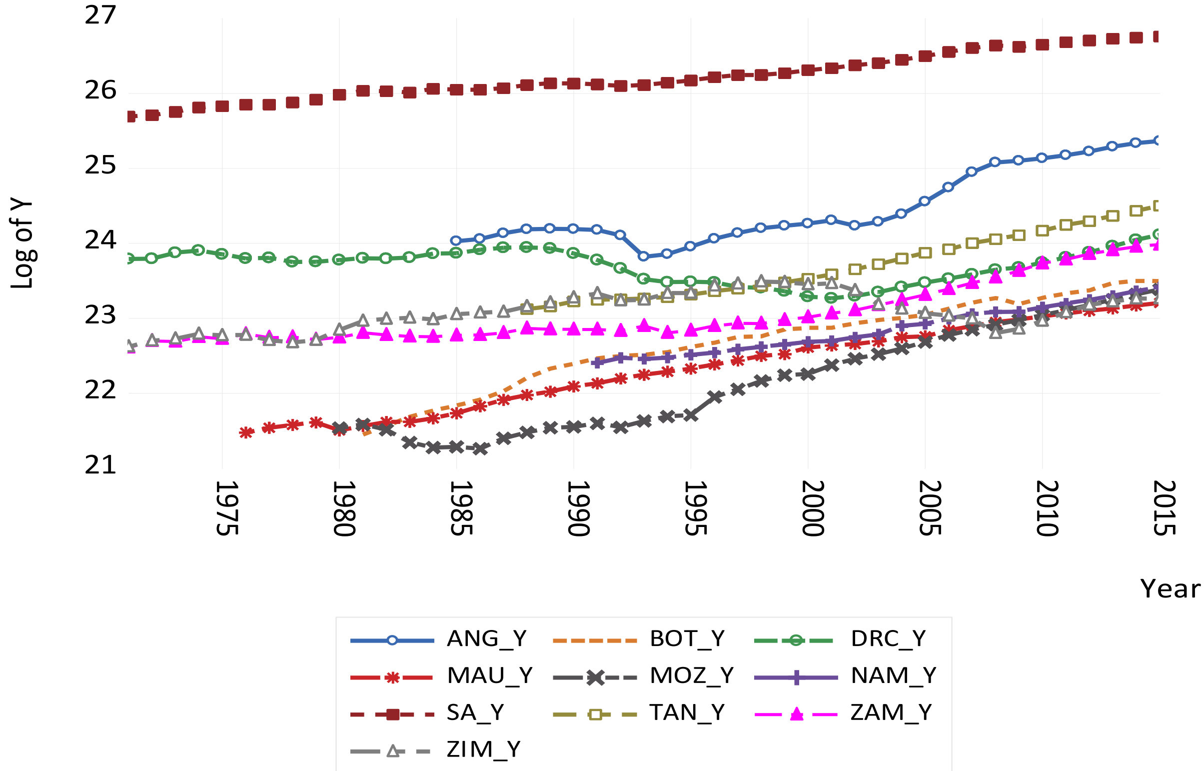


Figure 3: Trend diagram for economic growth



3. Brief review of literature

From the previous studies, a wide range of models is offered that investigated the relationship between economic growth and energy consumption, or what has been known as growth-energy nexus. It should be noted that these models tested the four hypotheses that are discussed below. First, the neutrality hypothesis assumes that there no causality between economic growth and energy consumption. The neutrality hypothesis implies that energy conservation will not lead to decreased economic growth and energy consumption will not be stimulated by economic growth. The recent studies that support the neutrality hypothesis include Ozturk and Acaravci (2010), Warr and Ayres (2010), Ozturk and Acaravci (2011), Stern and Enflo (2013), Aïssa, Jebli and Youssef (2014) and Bah and Azam (2017).

Second, the conservation hypothesis contends that there is unidirectional Granger causality running from GDP to energy consumption. This hypothesis implies that energy conservation policies may be implemented since they do not negatively affect economic growth. The Granger causality running from GDP to energy consumption was found in the studies by Abbasian, Nazary and Nasrindoost (2010), Jamil and Ahmad (2010), Azlina and Mustapha (2012), Haghnejad and Dehnavi (2012), Adom (2011), Baranzini et al. (2013), Damette and Seghir (2013), Ouedraogo (2013), Omri, and Kahouli (2014), Keho (2016) Odhiambo (2016) among others.

Third, the growth hypothesis argues that there is a unidirectional causality running from energy consumption to economic growth. This implies that increases in energy consumption may contribute to economic growth while restrictions on energy usage may negatively affect economic growth. Studies that have demonstrated this hypothesis include Chandran et al. (2010), Chang (2010), Odhiambo (2010), Lorde, Waithe and Francis (2010), Yoo and Lee (2010), Kouakou (2011), Mazbahul and Nazrul (2011), Haghnejad and Dehnavi (2012), Shahiduzzaman and Alam (2012), Al-Mulali and Sab (2012), Damette and Seghir (2013), Javid, Javid and Awan (2013), Ouedraogo (2013), Solarin and Shahbaz (2013), Acaravci and Ozturk (2013), Omri, and Kahouli (2014), Shahbaz et.al (2017) and Iyke (2015).

Finally, the feedback hypothesis assumes that there exists bi-directional Granger causality between economic growth and energy consumption. The implication of this is that an increase in the economic output will increase the level of energy consumption while an energy conservation policy will adversely affect the economic output. Studies by Ouédraogo (2010), Kouakou (2011), Belaid and Abderrahmani (2013), Hu and Lin (2013), Tang and Tan (2013), Shahbaz and Lean (2012), Zhang and Yang (2013), Sebri and Ben-Salha (2014), demonstrate this hypothesis. According to Karanfil (2009), Payne (2010) and Ozturk (2010) the relations between economic growth and energy consumption are often ambiguous and they attributed the differences in the results attributed to different econometric approaches, different time frames and different sets of variables used.

According to Shahateet (2014), these models have historically passed through four stages. In the first stage, the models were based on vector autoregression (VAR) methodology, such as Kraft and Kraft (1978) which did not account for the existence of unit roots in the variables included in the model. In the second stage, of the models, the studies did non-stationarity tests and applied Engle-Granger two-step procedure to test for cointegrating relationships in pairs of variables. In the third stage, the studies used multivariate estimators based on the Johansen (1991) approach, which allowed more than two variables in cointegrating relationships used for analysing causality. In the fourth stage, studies were based on testing for unit roots, cointegration and Granger causality plus other types of causality. According to Shahateet (2014), the results obtained using these models were inconclusive, sometimes controversial about the exact nature of the direction of the causality between energy consumption and economic growth. He went on to suggest that potential reasons for the differences in the results included the availability of data, the time periods examined, type of analysis, the econometric techniques and the variables included in the estimations and the method of estimation. Now that these techniques for carrying out research have been improved drastically, this gives rise to opportunities for further research with the aim of further guiding economic theories and economic planning to enhance economic growth and development. It should be noted that the situations under which different econometric methods are used are now unambiguously defined unlike what happened previously. This is the reason why the current study uses the VAR methodology.

Even though there are many studies that have been conducted on the causal relations between energy consumption and economic growth on groups of countries, very few studies have analysed the causal relationships in SADC countries. It should be noted that very few studies have explored energy-growth nexus for groups of countries.

Studies by Al-Mulali (2011) and Omri (2013) are good examples of these studies on MENA countries. The study by Al-Mulali (2011) examined the impact of oil consumption on the economic growth of the MENA countries during the period 1980–2009. The study employed the panel data model. The study found, using cointegration test results, that CO2 emission and oil consumption have a long run relationship with economic growth. In addition, the study found that there is also a bi-directional causality between oil consumption, CO2 emission and economic growth in both the short- and the long runs. His results demonstrated that oil consumption plays an important role in the economic growth of the MENA countries. Omri (2013) investigated the energy–environment–GDP nexus for 14 MENA countries. The study used simultaneous equations models estimated by the GMM-estimator and found that there exists a bi-directional causal relationship between energy consumption and economic growth and uni-directional causality from energy consumption to CO2. In addition, the study found that there exists a bi-directional causal relationship between economic growth and pollutant emissions.

Pao and Tsai (2010) examined dynamic causal relationships between pollutant emissions, energy consumption and output for a panel of BRIC countries over the period 1971–2005 excluding Russia (1990–2005). Their results show that energy consumption has a positive impact on emissions. They also found that energy-emissions and energy-output have bidirectional long-run causalities and that there are strong unidirectional causalities from emissions and energy to output.

Sebri and Ben-Salha (2014) also studied that the causal dynamics between economic growth, renewable energy consumption, CO2 emissions and trade openness for the BRICS countries for the period 1971–2010. Their study used the ARDL bounds testing approach to cointegration and vector error correction model (VECM) to examine the long-run and causal relationships between economic growth, renewable energy consumption, trade openness and carbon dioxide emissions. Using ARDL, they found that there exist long-run equilibrium relationships among the variables. Moreover, using the VECM they found bi-directional Granger causality between economic growth and renewable energy consumption, suggesting the confirmation of the feedback hypothesis in the BRICS countries.

Al-Mulali and Sab (2012) studied the impact of energy consumption and CO2 emission on the economic growth and financial development in the Sub-Saharan African countries using panel model for the period 1980 to 2008. The results demonstrated the importance of energy consumption in increasing both economic growth and the financial development in the investigated economies, but with the negative consequence of high pollution.

4. Data and methodology

To model the relationship between energy consumption and economic growth the author uses annual data for the period 1971–2015. As mentioned earlier the study includes 10 SADC countries: Angola, Botswana, Democratic Republic of Congo, Mauritius, Mozambique, Namibia, South Africa, United Republic of Tanzania, Zambia and Zimbabwe. It should be noted that the data for some countries is not available for the whole period. The latter countries include Mozambique, Namibia, Tanzania, Angola, Botswana and Mauritius with 36, 25, 28, 31, 35 and 40 observations, respectively, instead of the maximum of 45. Despite this, the data available for all the countries was enough for the method used and the available degrees of freedom to run the model.

The data used for both energy consumption (E) and real economic growth (Y) was obtained from the World Bank Group (2017). Y denotes real economic growth whose proxy is gross domestic product (GDP) while E denotes electricity consumption, and both are measured in constant 2010 US$s.

To obtain the Granger causality results, the author used the following four steps. First, I transformed all the variables to growth rates using the formulae $GY = @dlog(Y) \times 100$ and $GE = @dlog(E) \times 100$. In this case, GY is the growth rate of GDP and GE is the growth rate of energy consumption. Second, the author tested the transformed variables for non-stationarity to prove that they are all stationary in levels. Third, the author estimated the VAR models and also did the lag length, autocorrelation, heteroscedasticity and stability tests. In addition, the author also proved that there was no cointegration, stability and heteroscedasticity problems in all the VAR models estimated. Fourth, the author applied the Granger's causality test to determine the existence and direction of causality between the variables included in the model.

5. The model

I propose the Granger causality test for the case of two stationary variables GE_t and GY_t, which involve as a first step in the estimation the following VAR model:

$$GE_t = \alpha_1 + \sum_{i=1}^{n} \beta_i GY_{t-i} + \sum_{j=1}^{m} \delta_j GE_{t-j} + e_{GE_t} \quad (1)$$

$$GY_t = \alpha_2 + \sum_{i=1}^{n} \theta_i GY_{t-i} + \sum_{j=1}^{m} \psi_j GE_{t-j} + e_{GY_t} \quad (2)$$

Where GE is the growth rate of energy consumption and GY is the growth rate of aggregate output (GDP) and it is assumed that both e_{GE_t} and e_{GY_t} are uncorrelated white noise error terms (see Asteriou and Hall, 2015).

The letters m and n in equations (1) and (2) represent the maximum number of lags for each of the variables. The author decided to allow for different lags for each country and this meant that the author did not fix the maximum number of lags to a constant value. This means that the lag length is determined automatically by the least squares estimation method based on the Schwarz Information Criterion (SIC). The same models above are used for each of the countries studied.

The application of the VAR methodology is based on the following validations. First, VAR can only be applied when all the variables are either integrated of order zero or one, and in the case of the current study, all the variables are integrated of order zero. Second, one can estimate the level and the first difference relationship between variables using ordinary least squares method. Third, variables are not expected to have long run relationships since they are integrated of order zero.

The two Granger causality hypotheses that are tested for each country in this study are as follows. The first hypothesis is $H_0: \sum_{i=1}^{n} \beta_i = 0$ (economic growth does not Granger cause energy consumption) and $H_1: \sum_{i=1}^{n} \beta_i \neq 0$ (economic growth Granger causes energy consumption) and the second hypothesis is $H_0: \sum_{j=1}^{m} \psi_j = 0$ (energy consumption does not Granger cause economic growth) and $H_1: \sum_{j=1}^{m} \psi_j \neq 0$ (energy consumption Granger causes economic growth) (see Asteriou and Hall, 2015).

5.1 Non-Stationarity tests

Non-stationarity tests are considered important when estimating any model as they help ensure that least squares estimates are not spurious. The author want to test the null hypothesis that $H_{0:}\, \beta = 0$ (economic growth has a unit root) against it alternative that $H_{0:}\, \beta<0$ (economic growth is stationary) based on the following formula for the Augmented Dickey Fuller (ADF) test:

$$\Delta GY_t = \alpha + \beta GY_{t-1} + \sum_{i=1}^{k} \omega_i \Delta GY_{t-i} + \mu_{1t} \quad (3)$$

I also tested the null hypothesis that $H_{0:}\,\lambda = 0$ (economic growth has a unit root) against it alternative that $H_{0:}\,\lambda<0$ (economic growth is stationary) based on the following formula for the Phillips Perron (PP) test:

$$\Delta GY_{t-1} = \delta + \lambda GY_{t-1} + \mu_{2t} \qquad (4)$$

One can use similar formulae to get the energy consumption unit roots equations. The formulae (3) and (4) with constants only, can also be modified to include constant (intercept) and trend. In this case, μ_{1t} and μ_{2t} are white noise error terms and k is the maximum number of lags in equation (3). In addition, the critical values are obtained from the MacKinnon (1996) for unit root equations that have intercept only and intercept and trend. The data available in each country were adequate for these models.

6. Results and Discussion

Tables 1 and 2 present the non-stationarity test results. The results show that the growth rates of energy consumption and economic growth in all the countries are integrated of order zero. This means that no variables have unit roots. In other words, it is possible to employ the ordinary least squares and the vector autoregression methodologies on the individual equations and systems of equations, respectively, and get results that are not spurious and robust.

Table 1: ADF test for growth rates of Energy Consumption (E)

Variable	Model	Level	Decision
ANG_GE	Intercept	-5.005623***	No unit root
	Intercept and trend	-6.279329***	
BOT_GE	Intercept	-7.024180***	No unit root
	Intercept and trend	-6.906347***	
DRC_GE	Intercept	-6.845497***	No unit root
	Intercept and trend	-6.861715***	
MAU_GE	Intercept	-4.467180***	No unit root
	Intercept and trend	-4.474385***	
MOZ_GE	Intercept	-4.288093***	No unit root
	Intercept and trend	-4.224176**	
NAM_GE	Intercept	-4.985580***	No unit root
	Intercept and trend	-4.876282***	
SA_GE	Intercept	-4.857908***	No unit root
	Intercept and trend	-5.874282***	
TAN_GE	Intercept	-6.749071***	No unit root
	Intercept and trend	-6.653970***	
ZAM_GE	Intercept	-4.664527***	No unit root
	Intercept and trend	-4.751628***	
ZIM_GE	Intercept	-6.147464***	No unit root
	Intercept and trend	-6.098487***	

Notes: ***, and ** denotes significance at 1%, and 5% respectively. The maximum lag lengths, indicated between parentheses, are automatically chosen by the estimation method based on SIC. Unit root models with intercept and intercept and trend are chosen since adequate data is available for each country under study.

Table 2: ADF test for the growth rates of Economic Growth (Y)

Variable	Model	Level	Decision
ANG_GY	Intercept	-2.852463*	No unit root
	Intercept and trend	-3.065988*	
BOT_GY	Intercept	-4.127012***	No unit root
	Intercept and trend	-4.917003***	

DRC_GY	Intercept	-3.025439*	No unit root
	Intercept and trend	-3.634942**	
MAU_GY	Intercept	-5.813649***	No unit root
	Intercept and trend	-5.749416***	
MOZ_GY	Intercept	-3.619809**	No unit root
	Intercept and trend	-4.229867**	
NAM_GY	Intercept	-4.459084***	No unit root
	Intercept and trend	-5.675005***	
SA_GY	Intercept	-4.541414***	No unit root
	Intercept and trend	-4.483588***	
TAN_GY	Intercept	-1.219580	No unit root
	Intercept and trend	-3.566062*	
ZAM_GY	Intercept	-1.920383	No unit root
	Intercept and trend	-7.463772***	
ZIM_GY	Intercept	-4.139476***	No unit root
	Intercept and trend	-4.115072**	

Notes: ***, ** and * denotes significance at 1%, 5% and 10% respectively. The maximum lag lengths, indicated between parentheses, are automatically chosen by the estimation method based on SIC. Unit root models with intercept and intercept and trend are chosen since adequate data is available for each country under study.

6.1 Granger causality test results

Table 3 presents the Granger causality results when causality runs from real economic growth to energy consumption for all the SADC countries. First, the results reject the null hypothesis that real economic growth does not Granger causes energy consumption in Angola, Botswana, Democratic Republic of Congo, Mauritius, Namibia and Tanzania. Second, the results fail to reject the hypothesis of no causality in Mozambique, South Africa, Zambia and Zimbabwe. In addition, Table 4 presents the results of testing Granger causality that runs from energy consumption to real economic growth in all SADC countries. The results indicate that energy consumption Granger causes real economic growth in Botswana and Tanzania. Moreover, the results fail to reject the null hypothesis of no causality in all the other countries.

The results can alternatively be summarized as follows:

- There is unidirectional causality running from real economic growth to energy consumption in Angola, Democratic Republic of Congo, Mauritius, Namibia.
- There is bidirectional causality between energy consumption and economic growth in Botswana and Mauritius.
- There is no causality between energy consumption and economic growth in Mozambique, South Africa, Zambia and Zimbabwe.

Table 3: Results of Granger causality test for no causality from Y to E

Country	H_0: Y does not Granger cause energy consumption H_1: Y ⟶ E			
	Observations	**F-Statistic**	**Probability**	**Decision**
Angola	28	7.524865	0.0061	Y ⟶ E
Botswana	32	12.11261	0.0023	Y ⟶ E
DR Congo	43	5.167814	0.0230	Y ⟶ E
Mauritius	37	6.839535	0.0327	Y ⟶ E
Mozambique	34	1.962224	0.1613	No causality
Namibia	20	11.17001	0.0247	Y ⟶ E
South Africa	42	0.157966	0.6910	No causality

Tanzania	25	13.56522	0.0011	Y ⟶ E
Zambia	43	0.396400	0.5290	No causality
Zimbabwe	42	2.060937	0.3568	No causality

Table 4: Results of Granger causality test for no causality from E to Y

	H_0: E does not Granger cause energy consumption H_1: E ⟶ Y			
Country	**Observations**	**F-Statistic**	**Probability**	**Decision**
Angola	28	0.400901	0.5266	No causality
Botswana	32	4.935900	0.0848	E ⟶ Y
DR Congo	43	0.022930	0.8796	No causality
Mauritius	37	3.843656	0.1463	No causality
Mozambique	34	0.148835	0.6997	No causality
Namibia	20	7.645962	0.1054	No causality
South Africa	42	0.018301	0.8924	No Causality
Tanzania	25	9.024148	0.0110	E ⟶ Y
Zambia	43	1.197319	0.2739	No causality
Zimbabwe	42	2.010854	0.3659	No causality

6.2 Robustness checks

To test for the robustness of the results obtained, the study uses the parameter stability (Roots of Characteristic Polynomial), Autocorrelation LM, Jarque Bera Normality and the White heteroskedasticity tests. The results in Table 5 indicate that the VAR model for all the countries satisfies the stability condition. Next, the Autocorrelation LM test results show that the VAR models for all the countries do not suffer from autocorrelation. Finally, the White heteroscedasticity results also point to the fact that the VAR models for all the countries are free from heteroscedasticity. The Jarque Bera normality test (whose results are not shown here) under the descriptive statistics also showed that all the variables were individually normally distributed. The results obtained using all these tests confirm that the findings are reliable and robust.

Tale 5: VAR diagnostic checks

Country	Test	Decision
Angola 1985-2015	Autocorrelation LM test	No autocorrelation
	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	18.41219 (0.1037)
Botswana 1981-2015	Autocorrelation LM test	No autocorrelation
	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	34.41914 (0.0775)
DR Congo 1971-2015	Autocorrelation LM test	No autocorrelation
	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	24.68806 (0.0164)
Mauritius 1976-2015	Autocorrelation LM test	No autocorrelation
	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	32.32077 (0.1192)
Mozambique 1980-2015	Autocorrelation LM test	No autocorrelation
	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	25.06146 (0.0145)
Namibia 1991-2015	Autocorrelation LM test	No autocorrelation
	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	46.80418 (0.5219)
South Africa	Autocorrelation LM test	No autocorrelation

1971-2015	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	13.68469 (0.3213)
Tanzania 1988-2015	Autocorrelation LM test	No autocorrelation
	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	23.16450 (0.5101)
Zambia 1971-2015	Autocorrelation LM test	No autocorrelation
	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	15.72167 (0.2043)
Zimbabwe 1971-2015	Autocorrelation LM test	No autocorrelation
	Roots of Characteristic Polynomial	Stable
	Heteroscedasticity	23.21059 (0.5074)

7. Conclusions and future research

The study investigated the relationship between energy consumption and economic growth in 10 SADC countries using the VAR model over the period 1971 to 2015. The results indicate unidirectional causality running from real economic growth to energy consumption in Angola, Democratic Republic of Congo, Mauritius, Namibia, bidirectional causality between energy consumption and economic growth in Botswana and Mauritius and no causality in Mozambique, South Africa, Zambia and Zimbabwe. In countries where real economic growth Granger causes energy consumption the conservation hypothesis is confirmed. This implies that energy conservation policies may be implemented since they do not negatively affect economic growth. In addition, this means that shocks to energy supply will have an insignificant impact on economic growth. In countries where no causality was found the neutrality hypothesis is confirmed which implies that energy conservation will not lead to decreased economic growth and energy consumption will not be stimulated by economic growth. The feedback hypothesis is confirmed in Botswana and Mauritius and the implication of this is that an increase in the economic output will increase the level of energy consumption while an energy conservation policy will adversely affect economic output.

Differences between the results of this study and those of the previous studies done on individual economies may mainly be attributed to the different econometric approaches, time frames and types of variables used. The author, therefore, recommend that future researchers should use the same modern econometric methodology, time frames and variable types across all the SADC countries for them to be able to get good comparative results among the SADC member countries.

References

Abbasian, E., Nazari, M., Nasrindoost, M. (2010). Energy consumption and economic growth in the Iranian economy: Testing the causality relationship. *Middle-East Journal of Scientific Research* 5, 374-381.

Acaravci, A., Ozturk, I. (2010). Electricity consumption-growth nexus: evidence from panel data for transition countries. *Energy Economics* 32, 604–608.

Adom, P. K. (2011). Electricity consumption-economic growth nexus: The Ghanaian case. *International Journal of Energy Economics and Policy* 1, 18-31.

Aïssa, M. S. B., Jebli, M. B., & Youssef, S. B. (2014). Output, renewable energy consumption, and trade in Africa. *Energy Policy*, *66*, 11-18.

Al-Mulali, U. (2011). Oil consumption, CO2 emission and economic growth in MENA countries. *Energy*, *36*(10), 6165-6171.

Al-Mulali, U., & Sab, C. N. B. C. (2012). The impact of energy consumption and CO 2 emission on the economic growth and financial development in the Sub-Saharan African countries. *Energy*, *39*(1), 180-186.

Asteriou, D., & Hall, S. G. (2015). *Applied econometrics*. Palgrave Macmillan.

Azlina, A.A., Mustapha, N.H.N., (2012). Energy, Economic Growth, and Pollutant Emissions Nexus: The Case of Malaysia. *Procedia - Social and Behavioral Sciences* 65, 1-7.

Bah, M. M., & Azam, M. (2017). Investigating the relationship between electricity consumption and economic growth: Evidence from South Africa. *Renewable and Sustainable Energy Reviews*, *80*, 531-537.

Baranzini, A., Weber, S., Bareit, M., Mathys, N.A. (2013). The causal relationship between energy use and economic growth in Switzerland. *Energy Economics* 36, 464-470.

Bélaïd, F., Abderrahmani, F. (2013). Electricity consumption and economic growth in Algeria: A multivariate causality analysis in the presence of structural change. *Energy Policy* 55, 286-295.

Chandran, V. G. R., Sharma, S., Madhavan, K. (2010). Electricity consumption-growth nexus: The case of Malaysia. *Energy Policy* 38, 606-612.

Chang, C. C. (2010). A multivariate causality test of carbon dioxide emissions, energy consumption and economic growth in China. *Applied Energy* 87, 3533–3537.

Damette, O., Seghir, M. (2013). Energy as a driver of growth in oil exporting countries? *Energy Economics* 37, 193-199.

Haghnejad, A., Dehnavi, J. (2012). Energy consumption, economic growth, and pollution in selected OPEC countries: Testing the environmental Kuznets curve hypothesis. *Journal of Academic Research in Economics* 2, 149-166.

Iyke, B. N. (2015). Electricity consumption and economic growth in Nigeria: A revisit of the energy-growth debate. Energy Economics, 51, 166-176.

Jamil, F., Ahmad, E. (2010). The relationship between electricity consumption, electricity prices and GDP in Pakistan, *Energy Policy* 38, 6016-6025.

Javid, A.Y, Javid, M., Awan, Z.A. (2013). Electricity consumption and economic growth: Evidence from Pakistan. *Economics and Business Letters* 2, 21-32.

Karanfil, F. (2009). How Many Times Again Will We Examine the Energy–income Nexus Using a Limited Range of Traditional Econometric Tools? *Energy Policy*, 36, 1191–1194. http://dx.doi.org/10.1016/j.enpol.(2008).11.029.

Keho, Y. (2016). What drives energy consumption in developing countries? The experience of selected African countries. *Energy Policy*, *91*, 233-246.

Kouakou, A. K. (2011). Economic growth and electricity consumption in Cote d'Ivoire: Evidence from time series analysis. *Energy Policy* 39, 3638-3644.

Kraft, J., & Kraft, A. (1978). On the relationship between energy and GNP. The Journal of Energy and Development, 401-403.

Lorde, T., Kimberly, W., Brain, F. (2010).The importance of electrical energy for economic growth in Barbados. *Energy Economics* 32, 1411-1420.

Mazbahul, G.A., Nazrul, A.K.M. (2011). Electricity consumption and economic growth nexus in Bangladesh: Revisited evidence. *Energy Policy* 39, 6145–6150.

Odhiambo, N. (2010). Energy consumption, prices and economic growth in three SSA countries: A comparative study. *Energy Policy* 38, 2463–2469.

Odhiambo, N. M. (2016). Coal consumption and economic growth in South Africa: An empirical investigation. *Energy & Environment*, *27*(2), 215-226.

Omri, A. (2013). CO_2 emissions, energy consumption and economic growth nexus in MENA countries: Evidence from simultaneous equations models. *Energy Economics* 40, 657-664.

Ouedraogo, N. S. (2013). Energy consumption and economic growth: Evidence from the economic community of West African States (ECOWAS). *Energy Economics* 36, 637-647.

Ozturk, I. (2010). A literature survey on energy–growth nexus. *Energy Policy* 38, 340-349.

Ozturk, I., Acaravci, A. (2010). The Causal Relationship between Energy Consumption and GDP in Albania, Bulgaria, Hungary, and Romania: Evidence from ARDL Bound Testing Approach, *Applied Energy*, 87, 1938–43. http://dx.doi.org/10.1016/j.apenergy.(2009).10.010.

Ozturk, I., Acaravci, A. (2011). Electricity consumption and real GDP causality nexus: Evidence from ARDL bounds testing approach for 11 MENA countries. *Applied Energy* 88, 2885-2892.

Pao, H. T., & Tsai, C. M. (2010). CO 2 emissions, energy consumption and economic growth in BRIC countries. Energy Policy, 38(12), 7850-7860.

Payne, J. E., (2010). Survey of the international evidence on the causal relationship between energy consumption and growth. *Journal of Economic Studies* 37(1), 53-95.

Sebri, M., & Ben-Salha, O. (2014). On the causal dynamics between economic growth, renewable energy consumption, CO 2 emissions, and trade openness: fresh evidence from BRICS countries. *Renewable and Sustainable Energy Reviews*, *39*, 14-23.

Shahateet, M. I. (2014). Modeling economic growth and energy consumption in Arab Countries: Cointegration and causality analysis. *International Journal of Energy Economics and Policy*, *4*(3), 349.

Shahbaz, M., Lean, H. H., (2012). The dynamics of electricity consumption and economic growth: A revisit study of their causality in Pakistan. *Energy* 39, 146-153.

Shahbaz, M., Van Hoang, T. H., Mahalik, M. K., & Roubaud, D. (2017). Energy consumption, financial development and economic growth in India: New Evidence from a nonlinear and asymmetric analysis. Energy Economics, 63, 199-212.

Shahiduzzaman, M., Alam, K. (2012). Cointegration and causal relationships between energy consumption and output: Assessing the evidence from Australia. *Energy Economics* 34, 2182-2188.

Solarin, S. A., Shahbaz, M. (2013). Trivariate causality between economic growth, urbanization and electricity consumption in Angola: Cointegration and causality analysis. *MPRA Paper No.* 45580. Retrieved from http://www.mpra.ub.uni-muenchen.de/45580/

Stern, D. I., Enflo, K. (2013). Causality between energy and output in the long-run. *Lund Papers in Economic History*, No. 126.

Tang, C. F., Tan, E.C. (2013). Exploring the nexus of electricity consumption, economic growth, energy prices and technology innovation in Malaysia. *Applied Energy*, 104, 297-305.

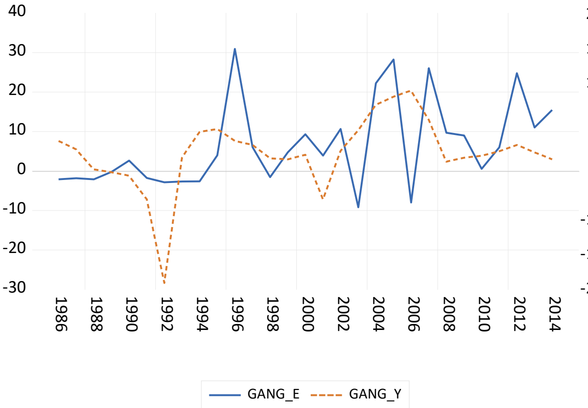
Warr, B. S., Ayres, R.U. (2010). Evidence of causality between the quantity and quality of energy consumption and economic growth. *Energy* 35, 1688-1693.

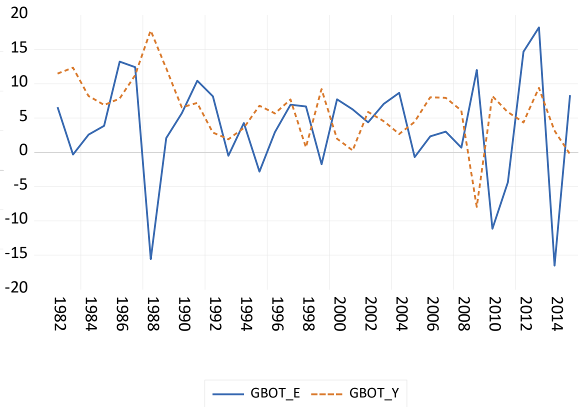
World Bank Group (Ed.). (2017). World Development Indicators 2012. World Bank Publications.

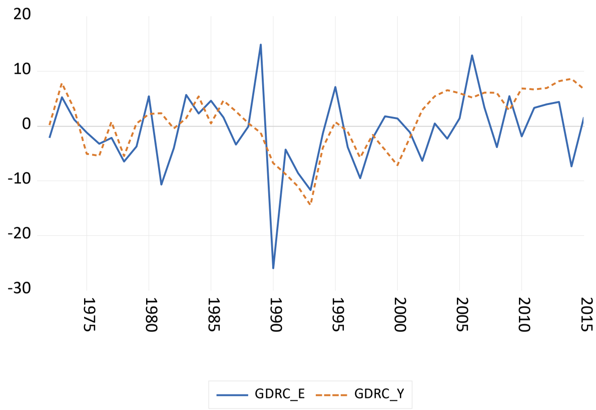
Yoo, S.H., Lee, Joo-S. (2010). Electricity consumption and economic growth: A cross-country analysis. *Energy Policy* 38, 622-625.

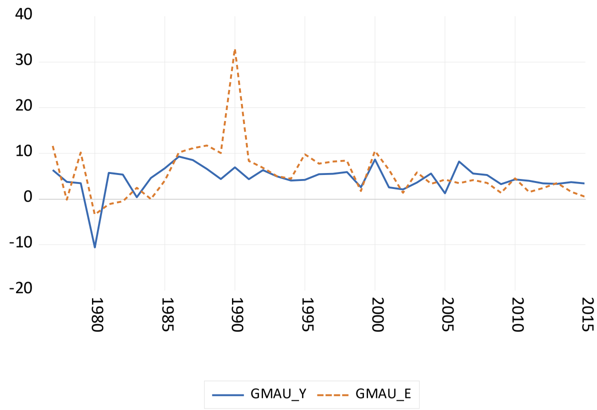
Zhang, W., Yang, S. (2013). The influence of energy consumption of China on its real GDP from aggregated and disaggregated viewpoints. *Energy Policy* 57, 76-81.

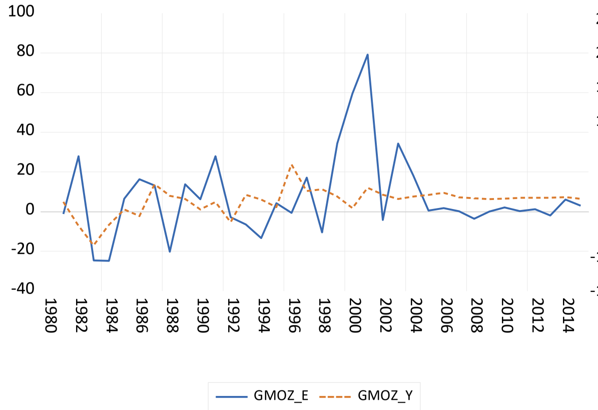
Appendix A

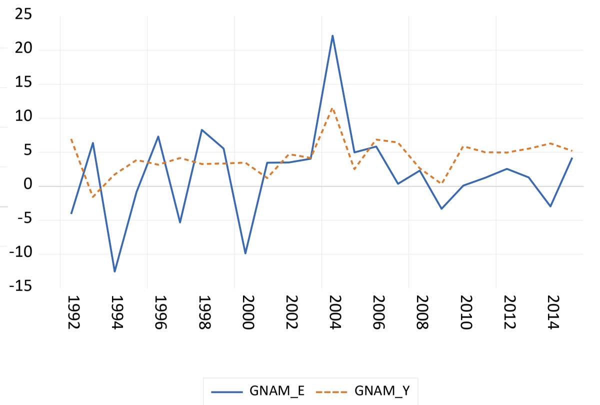


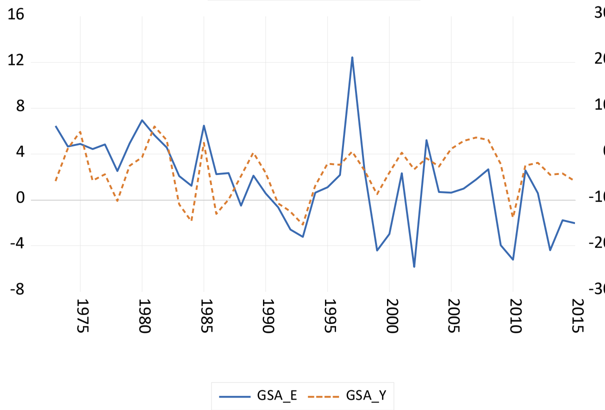


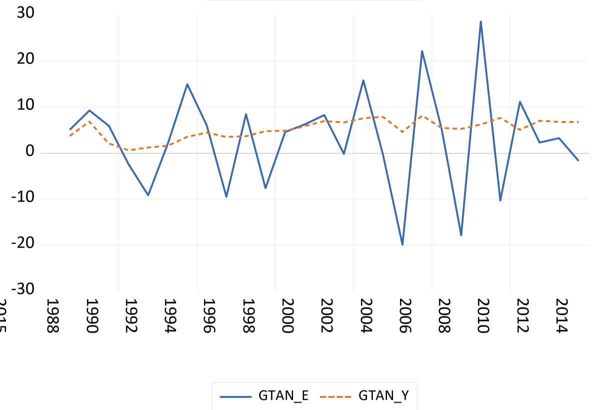

GDRC_E
GDRC_Y

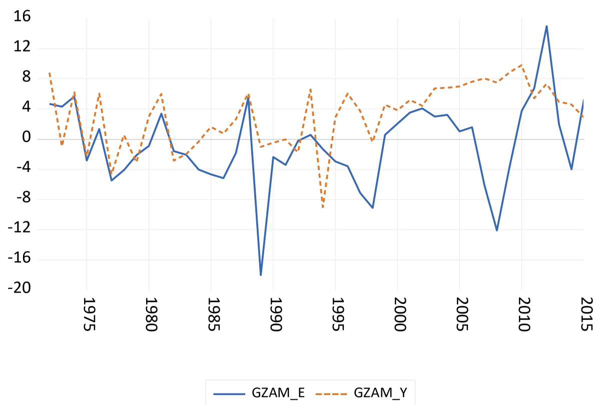

GMAU_Y
GMAU_E

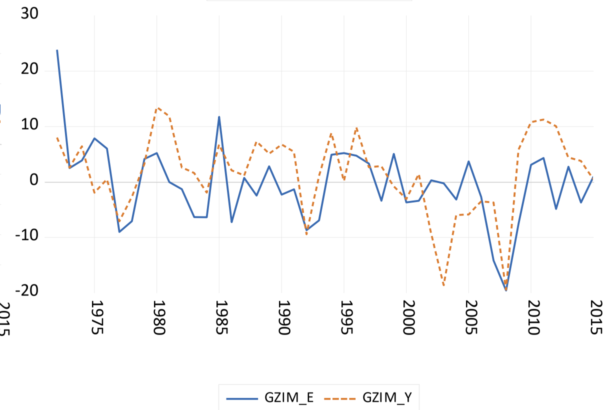

GMOZ_E
GMOZ_Y


GNAM_E
GNAM_Y


GSA_E
GSA_Y


GTAN_E
GTAN_Y


GZAM_E
GZAM_Y


GZIM_E
GZIM_Y