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ENERGY CONSUMPTION AND ECONOMIC GROWTH: EVIDENCE FROM COMESA COUNTRIES

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ABSTRACT

This study applies panel estimation techniques to investigate the long-run relationship between energy consumption and GDP for a panel of 18 African countries (COMESA). In the first step, we examine the degree of integration between GDP and energy consumption and find that the variables are integrated of order one. We also investigate the long-run relationship between energy consumption and GDP; our cointegration results provide strong evidence that GDP and energy consumption move together in the long-run. On a per-country basis, FMOLS results reveal that energy consumption has a positive long-run relationship with GDP. Finally, results from the panel error correction model show no evidence of a short-run transitory relationship between GDP and energy consumption; however, in the long-run, the error correction model captures a long-run bidirectional relationship between energy consumption and GDP. **JEL Classifications:** O13, O55, C52

INTRODUCTION

The post-independence era in the Sub-Saharan African region [hereafter SSA] witnessed a steady increase in the formation of regional economic communities [hereafter RECs]. The RECs were primarily aimed at promoting unity, enhancing sustainable development, increasing competitiveness, and integrating African countries into the global economy through mutual cooperation among member countries (World Energy Council, 2005). Our study region, the Common Market for Eastern and Southern Africa (COMESA), which is composed of 19 countries, was formed with the objective of promoting regional integration through trade development. Within COMESA, there are marked differences in the levels of development, physical infrastructure, and resource endowment.

Among other things, inadequate provision of modern energy services in SSA has long been considered to be a major constraint to economic growth and poverty alleviation efforts (UNECA, 2004). The United Nations [UN] has also underscored the importance of energy supply or access in achieving the UN Millennium Development Goals. Viewed in this light, in order for COMESA to boost regional integration and stimulate regional growth, there is a strong need to strengthen regional energy infrastructure. Capitalizing on the natural energy resource endowments of some member states, COMESA has developed protocols that provide for cooperation in energy development through the pooling of energy resources. In principle, these protocols are aimed at increasing energy accessibility and promoting economic growth.

The contributions of energy consumption to the growth process of a country have been a subject of debate among development economists for a long time. Although past studies have provided rich insights on the relationship between energy consumption and economic growth in SSA countries, there is a dearth of empirical analysis of the issue on any REC in Africa. This study aims to fill that gap by analyzing the relationship between energy consumption and economic on a panel of 19 COMESA countries. Inarguably, understanding the direction of causation between energy consumption and economic growth has important policy implications for COMESA countries, which are pursuing the common goal of increasing energy supply through regional energy cooperation and trade. The received implications of energy consumption for economic development and vice versa stem from the direct and indirect benefits which have been extensively discussed in previous studies (Toman and Jemelkova, 2003; Kraft and Kraft, 1978; Masih and Masih, 1996).

However, the few economic growth-energy consumption causality studies that have been conducted on SSA countries are based on individual countries and use time series analysis (Akinlo, 2008; Jumbe, 2004; Odhiambo, 2009; Wolde-Rufael, 2006). Distinct from previous studies, our study employs panel estimation techniques which have the ability to capture country-specific effects and are able to distinguish between a long-run and short-run relationship among the variables. In addition, the panel approach provides more data points than a single time series, and thus, the panel estimation technique has an additional advantage of increasing the degrees of freedom and reducing the problem of collinearity among the regressors (Levin, Lin, and Chu 2002).

The rest of the paper is organized as follows. The next section provides a summary of the economic and energy profile of COMESA countries; section 3 presents the literature review, while section 4 deals with the methodology and data sources. Section 5 provides a discussion of the empirical results, and section 6 contains conclusions and policy recommendations.

ECONOMIC AND ENERGY PROFILE OF COMESA

Formed in 1993, COMESA is composed of 19 African countries: Burundi, Comoros, Democratic Republic of Congo (DRC), Djibouti, Egypt, Eritrea, Ethiopia, Kenya, Libya, Madagascar, Malawi, Mauritius, Rwanda, Swaziland, Sudan, Seychelles, Uganda, Zambia, and Zimbabwe. Notably, COMESA is Africa’s largest regional economic community. In terms of volume, COMESA accounts for 2.5% of Africa’s economic activity. In 2007, COMESA had a combined population of 390 million people and a combined GDP of

US$361 billion. Within the region, there are marked structural differences in the national economies and levels of social development. Based on the World Bank classification of economies by income, 12 of COMESA member countries are listed as lower income while 7 are listed as lower middle income countries. Of the 19 COMESA countries, Libya has the strongest economy with a GDP per capita of US $ 10,840 (2007 dollars), while Burundi has the lowest GDP per capita of US $127.

Despite having significant reserves of coal, gas, geothermal, water, biomass, and other renewable energy resources, like the rest of Africa, energy consumption for COMESA countries is lower than the world average. With the exception of Egypt, Libya, Mauritius, and Seychelles, the percentage of population with access to electricity in COMESA countries ranges from 2 to 41% (COMESA, 2008). In terms of per capita energy consumption, Seychelles has the highest per capita energy consumption, followed by Libya; whereas Burundi has the lowest per capita energy consumption (table 1). In general, majority of the population in COMESA countries use low quality and inefficient sources of energy. Furthermore, energy intensity in COMESA countries is twice the world average (table 1). Combined, coal, oil, and gas account for the largest share of electricity generation.

Table 1
2005 Economic and Energy Profile of COMESA Countries

Name	GDP Current Prices (Billion $)	GDP Per Capita ($)	Population 2006 (million)	Energy Intensity (BTU/$ GDP)	Per Capita Consumption (BTU Million)	Income Category	Other
Burundi	1.0	127	.08	1,385	0.8	Lower income	HIPC
Comoros	0.4	682	0.69	3,342	2.3	Lower income	HIPC
DR Congo	9.9	161	62.38	6,124	1.6	Lower income	HIPC
Djibouti	0.8	1090	0.49	15,456	55.0	Lower Middle income	
Egypt	127.9	1739	78.95	6,551	32.2	Lower Middle income	
Eritrea	1.4	293	4.79	3,152	2.2	Lower income	HIPC
Ethiopia	15.9	206	74.78	1,517	1.4	Lower income	HIPC
Kenya	29.5	851	35.89	3,393	5.6	Lower income	
Libya	66.0	10840	5.9	13,048	132	Upper middle income	
Madagascar	7.3	371	18.87	2,362	2.2	Lower income	HIPC
Malawi	3.4	257	13.28	1,834	1.9	Lower income	HIPC
Mauritius	7.0	5572	1.25	2,779	44.3	Upper middle income	
Rwanda	2.8	303	9.64	1,231	1.4	Lower income	HIPC
Sudan	46.7	1257	38.57	3,148	4.8	Lower middle income	HIPC
Swaziland	2.7	2299	1.14	3,722	15.0	Lower middle income	
Seychelles	0.7	8852	0.08	13,833	155.6	Upper middle income	
Uganda	11.1	360	29.21	1,130	1.2	Lower income	HIPC
Zambia	10.9	895	11.29	9,961	11.1	Lower income	HIPC
Zimbabwe	16.2	1378	12.24	7,295	15.0	Lower income	
Total	361.6	896.6					

Source: Energy Information Administration (EIA) of U.S. Dept. of Energy except for GDP and GDP per capita. Both are from the official COMESA website (http://www.comesa.int/).

In view of the fact that more than 60 percent of COMESA countries are listed both as Least Developed Countries (LDCs) and Highly Indebted Poor Countries (HIPC) (1), energy provision will play a central role in poverty alleviation and sustainable development efforts, including achievement of the United Nations' Millennium Development Goals (MDG), which are to eliminate poverty by 2015. Hence, as COMESA countries' population and economies continues to grow demand for energy will concurrently increase, and if no measures are taken to boost energy supply, this may cause a further decline in per capita energy consumption.

LITERATURE REVIEW

Interest in the causal relationship between energy consumption and economic growth was spawned by Kraft and Kraft's (1978) seminal work. In general, empirical approaches to test the causal relationships between energy consumption and economic growth have been synthesized into four testable hypotheses (Apergis and Payne, 2009). The first hypothesis is that energy consumption is a prerequisite for economic growth given that energy is a direct input in the production process and an indirect input that complements labor and capital inputs (Toman and Jemelkova, 2003). In this case, a unidirectional Granger causality running from energy consumption to GDP means that the country's economy is energy dependent, and that policies geared at promoting energy consumption should be adopted in order to stimulate economic growth—because inadequate provision of energy may limit economic growth.

The second hypothesis asserts that when causality runs from economic growth to energy consumption, an economy is less energy dependent, and thus energy conservation policies, such as phasing out energy subsidies may not adversely affect economic growth. Ferguson et al. (2000) find strong evidence that an increase in wealth is positively related to energy consumption. The third hypothesis postulates that there is no causality between energy consumption and economic growth (also known as the neutral hypothesis). Thus, policies aimed at conserving energy will not retard economic growth (Asafu-Adaye, 2000; Jumbe, 2004). Finally, the fourth hypothesis assumes a bidirectional relationship between energy consumption and economic growth. The implication of the bidirectional relationship is that energy consumption and economic growth are complementary, and that an increase in energy consumption stimulates economic growth, and vice-versa.

By and large, empirical research on the energy consumption-economic growth nexus has yielded mixed results, mainly because of estimation techniques, choice of study period, and level of development of the country being studied. In recent years panel estimation techniques have become popular because of their ability to capture country-specific effects. In addition, panel estimations have the advantage of improving the degrees of freedom as well as allowing for heterogeneity in the direction and magnitude of the parameters.

Lee (2005) applies panel estimation techniques to 18 developing countries, including sub-Saharan African Kenya and Ghana. Lee (2005) finds evidence of causality running from energy consumption to GDP. Also, Lee et al. (2008) use a panel error correction model to examine the short-run and long-run causality between energy consumption and economic growth for a panel of 22 OECD countries. Their results show a bidirectional relationship between energy consumption, capital stock, and GDP. Similarly, Mehrara (2006) applies panel estimation techniques to 11 oil exporting countries and finds evidence of a strong unidirectional causality running from energy consumption to per capita

GDP. In a recent effort, Ciarreta and Zarraga (2008) apply the heterogeneous panel cointegration tests and panel system GMM to estimate the causal relationship between economic growth and electricity consumption for 12 European countries. They find no evidence of a short-run causal relationship, but establish a long-run relationship running from electricity consumption to GDP.

Chen et al. (2007) also employ a dynamic panel error correction model on a panel of 10 Asian developing countries. Results from Chen et al. indicate a bidirectional relationship between electricity consumption and economic growth in the long-run, while causality runs from electricity consumption to economic growth only in the short-run. Apergis and Payne (2009, 2010) examine the causal relationship between energy consumption and economic growth for a panel of 11 countries of the Commonwealth of Independent States (2). They find unidirectional causation from energy consumption to economic growth in the short-run, and a bi-directional relationship between energy consumption and growth of real output in the long-run. In general the empirical literature shows that energy consumption stimulates economic growth, and vice versa.

METHODOLOGY

Previous studies have examined the relationship between energy consumption (electricity consumption) and economic growth in Sub-Saharan Africa using country-level data and time-series techniques. In this study, we employ panel estimation techniques to determine the dynamic relationship between energy consumption and economic growth. The methodology adopted in this study uses a three-step procedure. First, panel unit root tests are applied to test the degree of integration between economic growth and energy consumption. Second, panel cointegration techniques proposed by Pedroni (1999) are applied to determine the long-run relationship between energy consumption and GDP. The long-run equation for energy consumption and GDP is estimated using the fully modified ordinary least squares (FMOLS). Finally, a dynamic panel error correction model is applied to determine the direction of causation in the short-run and long-run.

Panel Unit Root Tests

Panel unit root tests are used to examine whether the variables are integrated to the same order. In this study, we examine whether GDP and energy consumption are stationary. Various panel unit root methodologies have been proposed, including Maddala and Wu (1999), Baltagi and Kao (2000), Choi (2004), Hadri (2000), Levin et al. (2002), and Im et al. (2003). In this study, we test for unit roots using three panel-based methods proposed by Levin et al. (2002), hereafter referred to as LLC, Im et al. (2003), hereafter referred to as IPS, and Hadri (2000). For each estimation technique, we test for unit roots in the panel using two types of models (2). Two variants of each model are estimated. In the first model, the variables (LGDP and LEC) are estimated in level form with and without a deterministic trend, while in the in the second model, the first difference of the variables ($\Delta LGDP$ and (ΔLEC) are estimated with and without a deterministic trend.

The LLC test presumes that all series are stationary and that δ in equation (1) is homogenous across the panel under the alternate hypothesis. In general, the LLC test is the most widely used panel unit root test and can be specified as follows:

$$\Delta Y_{it} = \alpha_i + \delta_i Y_{it-1} + z'_{it}\gamma + e_{it}$$
(1)

where Δ is the first difference operator, y_{it} is the series of observations for country i; $t = 1, 2, \dots T$ time series observations, z'_{it} is the deterministic component and e_{it} are independently and normally distributed random variables. The test has the null hypothesis of $H_0: \delta_i = \delta = 0$ for all i against the alternative hypothesis of $H_a: \delta_i = \delta < 0$ for all i. In general, the LLC test is based on the pooled t-bar statistic of the estimator and thus provides higher power than individual observation unit root estimation.

Unlike the LLC which makes the assumption that the autoregressive parameters (δ) are homogenous across panels, the IPS test relaxes this assumption. The IPS test allows for heterogeneity in the coefficient of δ under the alternative hypothesis and. This is achieved by using separate unit root tests for the N-cross section units and tests the following hypotheses: $H_0: \delta_i = 0$ for all i against the alternative hypothesis of $H_a: \delta_i < 0$ for all i. Referring to equation (1), the IPS substitutes δ_i for δ. In essence, the IPS test is based on the t- bar statistic for each cross section unit and allows for some of individual series to have unit roots.

The Hadri test is a residual-based Lagrange Multiplier test. The test statistic is one-sided, with the null hypothesis that all series in the panel are stationary.

Panel Cointegration

After determining that the variables are integrated of order one, the second step of our empirical work involves examining whether there is any long-run relationship between the integrated variables. We employ Pedroni's (1999, 2000) panel cointegration techniques. These techniques allow for heterogeneity among individual members of the panel and are thus an improvement over conventional cointegration tests which assume that the vectors of cointegration are homogenous. Following Pedroni, the cointegration relationship to be estimated is specified as follows:

$$LGDP_{it} = \alpha_{it} + \delta_i t + \beta_1 LEC_{it} + \varepsilon_{it} \qquad (2)$$

Where LEC and $LGDP$ are the natural logarithms of the observable variables of energy consumption per capita and gross domestic product per capita, respectively;$t = 1, \dots T$ are time periods; $i = 1, \dots, N$ are panel members;α_i denotes country-specific effects, δ_t is the deterministic time trends, and ε_{it} is the estimated residual from the panel regression. The structure of the estimated residual follows:

$$\varepsilon_{it} = \rho_i \varepsilon_{it-1} + \mu_{it}$$

The estimated residual indicates the deviation from the long-run relationship. With the null of no cointegration, the panel cointegration is essentially a test of unit roots in the estimated residuals of the panel.

Pedroni (1999) shows that there are seven different residual statistics for the cointegration test: (1) the panel v −statistic; (2) panel ρ − statistic; (3) Panel (PP)-statistic; (4) panel Augmented Dickey-Fuller (ADF)-statistic; (5) group ρ–statistic ; (6) group PP-statistic; and (7) group ADF-statistic. The first four statistics are known as panel cointegration statistics and are based on the within-dimension approach. The within-dimension imposes a common ($\rho_i = \rho$) coefficient by pooling the autoregressive coefficients across different members for the unit root tests on the estimated residuals. The within-dimension tests the following hypotheses: $H_0: \rho = 1\ \forall_i$ against the alternate $H_1: \rho_i = \rho < 1$.

The last three statistics are group panel test statistics and are based on the between-dimension approach. Unlike the within approach which impose a common coefficient under the alternate hypothesis, the between- dimension allows for heterogeneous coefficients by averaging the individually estimated coefficients of each country. The hypotheses for the between-dimension approach are stated as $H_0: \rho = 1$ for all i, against the alternate hypothesis of $H_1: \rho < 1$. In the presence of a cointegrating relationship, the residuals are expected to be stationary. The panel *v*-test is a one-sided test, with the null of no cointegration being rejected when the test has a large positive value. The other tests reject the null hypothesis of no cointegration when they have large negative statistics.

Once cointegration has been established, the third step involves estimating the long-run relationship between energy consumption and GDP (equation 2), using the panel Fully Modified OLS (FMOLS) due to Pedroni (2000). The FMOLS technique accounts for both serial correlation and endogeneity problems and thus provides asymptotically unbiased estimates than simple OLS estimation. Another advantage of the FMOLS is that the FMOLS technique allows for heterogeneity among individual members of the panel while estimating the long-run relationship.

Panel Granger Causality Tests

If the variables LGDP and LEC are cointegrated, then causality exists between the two series; however, this does not indicate the direction of causality. To test for Granger causality in the short-run and long-run, we employ a two-step process. The first step involves the estimation of the residuals from the long-run model (equation 2), while the second step involves fitting the estimated residuals as a right-hand variable in a dynamic error correction model (ECM) (3). The dynamic error correction model used is specified as follows:

$$\Delta LGDP_i = \alpha_1 + \beta_1 ECT_{t-1} + \beta_2 \Delta LGDP_{t-1} + \beta_3 \Delta LGDP_{t-2} + \beta_4 \Delta LEC_{t-1} + \beta_5 \Delta LEC_{t-2} + \varepsilon_1$$
(3)

$$\Delta LEC_i = \alpha_2 + \delta_1 ECT_{t-1} + \delta_2 \Delta LGDP_{t-1} + \delta_3 \Delta LGDP_{t-2} + \delta_4 \Delta LEC_{t-1} + \delta_5 \Delta LEC_{t-2} + \varepsilon_2$$
(4)

Where Δ denotes the difference operator; ECT_{t-1} is the lagged error correction term derived from the long-run cointegrating relationship; β_1 and δ_1 are adjustment coefficients; and ε_1 and ε_2 are disturbance terms.

We first identify the sources of causation by testing for the significance of the coefficients on the lagged dependent variables in equations (3) and (4). The short-run Granger causality (weak causality) tests the following hypotheses: $H_0: \beta_4 = \beta_5 = 0$ for all i in equation (3) and $H_0: \delta_2 = \delta_3 = 0$ for all i in equation (4).

After testing for short-run causality, the long-run causality is tested by looking at the significance of the coefficient of the error correction terms ($\beta_1$and δ_1) in equations (3) and (4). The significance of β_1 and δ_1 indicates the long-run relationship of the cointegrated process; hence movements along this path are considered permanent because changes in the endogenous variables are not only caused by the lagged values but also by the previous period's disequilibrium. Again, in order to examine the long-run causality relationship, we test $H_0: \beta_1 = 0$ for all i in equation (3) and $H_0: \delta_1 = 0$ for all i in equation (4). If $\beta_1 = \delta_1 = 0$ for all i then there is no Granger causality in the long-run.

It is also noteworthy that the error correction term combines the long run and short run movements of the cointegrated variables towards the long run equilibrium. Thus, besides examining the short-run and long-run relationships of the two variables, we conduct a joint hypothesis test of $H_0: \beta_1 = \beta_4 = \beta_5 = 0$ for all i in equation (3) and $H_0: \delta_1 = \delta_2 = \delta_3 = 0$ for all i in equation (4). The significance of the causality tests is determined by the Wald F-test. This joint hypothesis test is also referred to as the strong Granger causality test and is used for determining the variables which bear the burden of short-run adjustment to re-establish long-run equilibrium, following a shock to the system (Asafu-Adjaye, 2000 and Lee, 2005). A result of no causality in either direction indicates that the variables have a neutral effect on each other.

DATA

Data used in this analysis are pooled annual time series for real GDP (hereafter referred to as GDP) and energy consumption (EC hereafter) for 19 COMESA countries for the period 1980 to 2005. BTU of energy is used as a proxy for energy consumption (*EC*), and this data is obtained from United States Energy Information Administration (EIA). GDP data come from the International Monetary Fund' (IMF) *World Economic Outlook 2008*. All variables used in the estimation are in natural logarithm form.

RESULTS

Panel Unit Root Results

The results of the IPS, LLC and Hadri panel unit root tests for the series LGDP and LEC are shown in table 2. The unit root statistics reported are for the level and first differenced series of LGDP and LEC. As can be seen from table 2, with the exception of the LLC and Hadri tests, the IMS fails to reject the null hypothesis of non-stationarity when the variables are in level form. However, the hypothesis of non-stationarity is rejected at the 1% significance level when series are first differenced, and thus confirm that LGDP and LEC are integrated of order one (I(1)).

Table 2
Panel Unit Root Results for LGDP and LEC, 1980-2005

Variable	IPS Test		LLC Test		Hadri Test	
	With No Trend	**With Trend**	**With No Trend**	**With Trend**	**With No Trend**	**With Trend**
Model 1: Individual Effects in Level Form with No Time Trend and With Time Trend						
LGDP	0.7621 (1.00)	0.7461 (0.89)	-3.017^{**} (0.007)	-0.9799 (0.19)	15.078^{***} (0.000)	8.362^{***} (0.000)
LEC	0.531 (0.79)	-1.115 (0.49)	-1.935^{*} (0.042)	-1.685^{*} (0.020)	11.821^{***} (0.000)	8.768^{***} (0.000)
Model 2: Individual Effects and First Difference with No Time Trend and With Time Trend						
ΔLGDP	-12.016^{***} (0.000)	-10.819^{***} (0.000)	-10.355^{***} (0.000)	-8.463^{***} (0.000)	3.489^{***} (0.000)	6.720^{***} (0.000)
ΔLEC	-16.296^{***} (0.000)	-15.782^{***} (0.000)	-18.0830^{***} (0.000)	-16.1108^{***} (0.000)	3.983^{***} (0.000)	7.0623^{***} (0.000)

Note: ***, **, and * indicate rejection of the null hypothesis at the 1%, 5%, and 10% significance levels, respectively.
P-values are shown in parenthesis

Panel Cointegration Results

Having confirmed that the variables are integrated of order one, the next step is examine existence of the long-run relationship. Table 3 reports the results of the panel cointegration. The first four rows report the computed test statistics for the within-dimension--which is based on estimators that pool the autoregressive coefficient across different countries. The within-dimension estimates show that only the panel pp type-t statistic and the panel v-statistic reject the null of no cointegration at the 5% and 1% significance levels, respectively. On the other hand, the between dimension estimates show that the null hypothesis of no cointegration is rejected by the group pp type ρ–statistic and the group pp t-statistic at 5% significance level, respectively. Overall, the rejection of no-cointegration confirms that a long-run relationship between LGDP and LEC exists.

Table 3
Panel Residual Cointegration Results, 1980-2005

Statistic	Intercept and no time trend	Intercept and time trend
Panel Cointegration Statistics (Within-Dimension)		
Panel v-statistics	0.9450 (0.999)	5.5994*** (0.000)
Panel ρ type-statistics	−1.2997 (0.312)	0.8346 (0.133)
Panel PP type t- statistics	−3.2081** (0.003)	0.1221(0.101)
Panel ADF type t- statistics	0.4158 (0.165)	1.4750 (0.222)
Group Panel Mean Cointegration Statistics (Between-Dimension)		
Group PP type ρ - statistics	0.3434 (0.788)	1.8277* (0.043)
Group PP t- statistics	−2.0133* (0.067)	0.3005 (0.822)
Group ADF type- statistics	0.9422 (0.178)	0.6103 (0.575)

Note: ***, **, and * indicate rejection of the null hypothesis at the 1%, 5%, and 10% significance levels, respectively.
P-values are shown in parenthesis and the number of lag truncations is based on Newey and West (1987) bandwidth and is fixed at 1.

Having established that the two variables (LGDP and LEC) are cointegrated, we estimate the long-run relationship between GDP and energy consumption (EC) using the FMOLS. Table 4 reports the results for the FMOLS. For a panel of 18 countries (4), the coefficient for energy consumption (EC) is statistically significant and positive at the 1% significance level. According to these estimates, a 10% increase in energy consumption for the entire COMESA region will increase GDP per capita by 2.12 percent. Our results are consistent with earlier studies on the relationship between GDP and energy consumption for SSA countries. The elasticity estimates for energy consumption are comparable to those obtained by Lee (2005) for Sub-Saharan African countries.

Individual country results shows that the elasticity of energy consumption with respect to GDP is positive for all COMESA countries. Nonetheless, the coefficients for energy consumption fail to attain any statistical significance for Madagascar, Rwanda, and Sudan. The elasticity of energy consumption ranges from 0.101 (Lesotho) to 1.753 (Uganda). Overall, these results suggest that an increase in energy consumption in COMESA countries tends to stimulate economic growth and thus strong energy policies are required in order to stimulate and sustain economic growth.

Table 4
Panel FMOLS Results (Dependent Variable: ΔLGDP)

Country	Δ LEC	ρ-value
Burundi	0.570***	0.000
Comoros	0.464***	0.000
Democratic Republic of Congo (DRC)	0.361***	0.000
Djibouti	0.270***	0.000
Egypt	0.711**	0.006
Ethiopia	0.661***	0.000
Kenya	0.886**	0.002
Lesotho	0.101**	0.007
Libya	0.424***	0.000
Madagascar	0.369	0.787
Malawi	0.372**	0.005
Mauritius	0.777***	0.000
Rwanda	0.449	0.861
Seychelles	0.477*	0.041
Sudan	0.652	0.889
Swaziland	0.303*	0.022
Uganda	1.753***	0.000
Zambia	0.421***	0.000
Zimbabwe	0.316***	0.000
Panel	**0.212*** **	0.000

*Significant at 10%, **Significant at 5%, and ***Significant at 1%

Granger Causality Results

Given that the variables are cointegrated, we proceed to report the estimates from the dynamic panel error correction model which performs the Granger Causality test. Short-run Granger causality results shown in table 4 indicate that both LGDP and LEC are not statistically significant at any level—which implies that they do not Granger cause each other in the short run. This finding confirms that energy and GDP have a neutral effect on each other. One plausible explanation for the neutral effect is that the amount of energy used in the production system in COMESA countries is very small to the extent that GDP growth is not stimulated.

A further examination of table 5 shows that the error correction terms in equations (3) and (4) are statistically significant, which is evidence of a long-run permanent relationship between energy consumption and GDP. This suggests that energy consumption and GDP are interdependent in COMESA member countries. This confirms that energy is a pre-requisite for growth in the long-run.

In addition, in both the GDP and the energy consumption equation, the joint F-test for the short-run and long-run relationship is significant. This confirms presence of a strong two-way Granger causality between the GDP and energy consumption. Overall, these findings suggest that changes in GDP have an impact on changes in energy consumption and vice-versa in the long-run. Intuitively, this means that energy conservation policies can have detrimental effects on the overall performance of the economy.

Finally, our findings are consistent with Akinlo (2008), Asafu-Adjaye (2000), and Lee's (2005) work in revealing a bidirectional relationship between energy consumption and GDP for a subset of Sub-Saharan African countries.

Table 5
Results of Panel Causality Tests (All COMESA Countries)

Dependent Variable	Sources of Causation				
	Short Run		Long-run	Joint (short run/ long run)	
	ΔLGDP	*ΔLEGC*	*ECT(-1)*	*ΔLGDP, ECT(-1)*	*ΔLEGC, ECT(-1)*
ΔLGDP	-	F=1.08	F= 9.31***	-	F= 4.9**
ΔLEGC	F =0.59	-	F= 17.76***	F =6.06***	-

*Significant at 10%, **Significant at 5%, and ***Significant at 1%,

CONCLUSIONS AND POLICY RECOMMENDATIONS

The purpose of this study was to test for Granger causality between energy consumption and GDP in COMESA countries using panel causality tests. For a panel of 18 countries, we find that there is no short-run transitory relationship between GDP and energy consumption, but in the long-run, there is a long-run bidirectional relationship between energy consumption and GDP. Given that energy is an input in the production system, this suggests that low access to energy in COMESA member countries may constrain growth prospects.

The findings in this study suggest that policymakers should focus on developing policy frameworks that are aimed at stimulating economic growth and increasing energy accessibility for COMESA member countries. In particular, policy frameworks directed towards stimulating investment in alternative energy sources and those aimed at increasing real income should be vigorously pursued. The significant hydro-electric and geothermal potentials, and the other proven natural energy resources in COMESA countries should be tapped into to reliably supply low-cost energy to the region.

Secondly, in an effort to address the energy poverty problem, we recommend that COMESA countries harmonize and coordinate energy policies within the context of regional economic integration. Regional energy integration will invariably enhance productivity, trade, and competitiveness of member countries, and this will subsequently translate into improved economic and social development. Lastly, it should be pointed out that the prospects of regional economic integration to boost economic growth and social welfare cannot be achieved without the integration of labor markets, and physical infrastructure—such as energy, roads, telecommunications, and other resources.

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ENDNOTES

1. Information about HIPC countries and standards are available from the International Monetary Fund at http://www.imf.org/external/np/hipc/index.asp.

2. For a detailed discussion of panel unit root tests, see Levin, Lin and Chu; Hadri (2000); and Im, Pesaran, and Shin (2003).

3. The lag length in the dynamic panel error correction model is based on the Akaike and Schwarz Bayesian Information criteria and both criteria indicate that two lags as the optimal lag length.

4. Due to lack of data, Eritrea was excluded from the sample; hence, the number of countries in our analysis was reduced to 18.