“Energy consumption and economic growth in Mozambique: an empirical investigation”

AUTHORS	Angelique G. Nindi Nicholas Odhiambo

ARTICLE INFO	Angelique G. Nindi and Nicholas Odhiambo (2014). Energy consumption and economic growth in Mozambique: an empirical investigation. *Environmental Economics*, *5*(4)
RELEASED ON	Thursday, 27 November 2014
JOURNAL	"Environmental Economics"
FOUNDER	LLC “Consulting Publishing Company “Business Perspectives”

Angelique G. Nindi (South Africa), Nicholas M. Odhiambo (South Africa)

Energy consumption and economic growth in Mozambique: an empirical investigation

Abstract

In this paper, we examine the causal relationship between energy consumption and economic growth in Mozambique – using modern time-series techniques. Unlike some of the previous studies, the current study has used the recently developed ARDL-bounds testing approach to co-integration and the ECM-based Granger causality method to examine this linkage. To our knowledge, this might be the first study of its kind to examine the causal relationship between energy consumption and economic growth in Mozambique – using the recently developed ARDL-bounds testing approach. The empirical findings of our study show that there is a long-run relationship between energy consumption and economic growth in Mozambique. The results also show that there is a distinct unidirectional causality from energy consumption to economic growth. This implies that, for Mozambique, it is the consumption of energy that drives economic growth, and not vice versa. This finding applies both in the short run and in the long run. The study, therefore, recommends a rapid expansion of the energy infrastructure in Mozambique, in order to enable the country to cope with the expected future increase in energy demand.

Keywords: energy consumption, economic growth, ARDL-bounds testing approach, Mozambique.
JEL Classification: C320, Q430, O130.

Introduction

The causal relationship between energy consumption and economic growth has been extensively examined in the economic literature – in the case of developed and developing countries. However, empirical studies on the energy-growth nexus have not been able to reach a consensus on the linkage between these two economic variables. This has been attributed to a number of factors that are heterogeneous to countries: such as, climate conditions, the structure and stages of economic development within a country, varying indigenous energy supplies and consumption patterns, different political and economic histories, and the alternative econometric methodologies employed, among other things (Ozturk, 2010; Payne, 2008; Chen et al., 2007).

Furthermore, studies on developing countries have been focused mainly on Asian and Latin-American countries, with only a few studies being done on sub-Saharan African (SSA) countries. Some of the previous studies on the latter group of countries have relied on cross-sectional analyses, which by virtue of lumping together countries at different stages of development; fail to account for the factors that are specific to individual countries (Odhiambo, 2009). In addition, there have been suggestions that the causal relationship between energy consumption and economic growth is sensitive to a country's level of income (Odhiambo, 2014; Huang et al., 2008).

The present study, therefore, adds to the available literature – by examining the causal relationship between energy consumption and economic growth in Mozambique. The recent discovery of natural gas and coal resources in the country, coupled with the fact that Mozambique exports a significant proportion of its energy resources to Southern and East African countries, implies that the contribution of the energy sector to economic growth will likely rise in the future. To the best of our knowledge, this is the first study to examine the dynamic linkage between energy consumption and economic growth in the country.

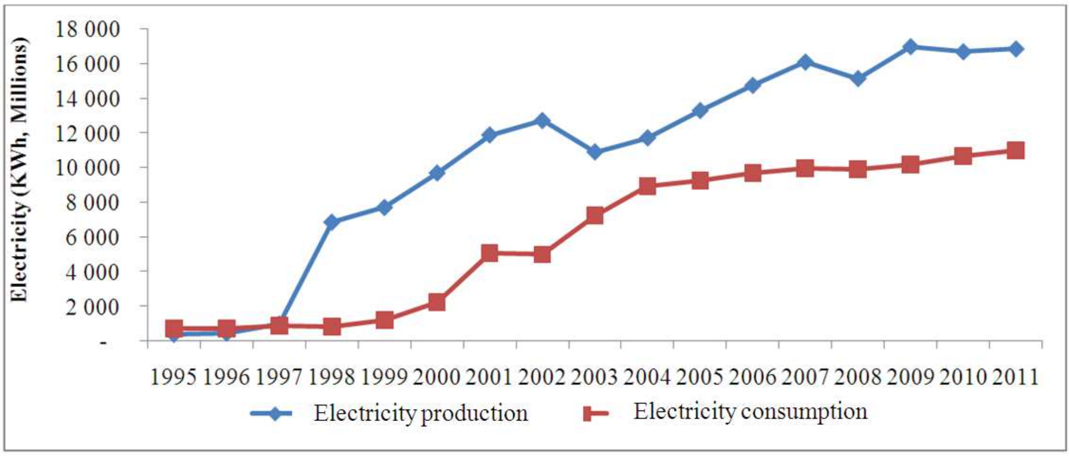
To address this issue, the current study makes use of the recently developed autoregressive distributed-lag (ARDL) bounds-testing procedure to determine the causal relationship between these two variables. The rest of the study is organized as follows: Section 1 provides an overview of the energy policies in Mozambique; while Section 2 reviews the literature. Section 3 discusses the estimation techniques used in the analysis, as well as the regression results. Lastly, the final section concludes the study.

1. Overview of the energy sector in Mozambique

Mozambique has vast and untapped energy resources, which consist mainly of hydropower, coal, natural gas, and oil. These resources enable the country to meet its internal demands, and still export energy to Southern and East African countries. Consequently, energy exports account for a significant portion of foreign exchange earnings in the country.

Currently, hydropower is the main source of electricity in the country, with electricity generated from this resource having accounted for over 99% of the total electricity produced in the past decade (World Bank, 2014). The hydropower potential is estimated to be close to 12,000 MW, with a corresponding total energy output of 60,000 GWh/yr. Electricity is provided through the national grid, managed by the national power utility, Electricidade de Moçambique. There are isolated grids that provide electricity for people in the rural areas; and these are mainly powered by diesel generators.

However, only about 38% of the total population have access to electricity (Ministry of Energy, 2013). The majority of the population rely on non-commercial energy or traditional forms of energy (i.e., biomass and waste, such as wood, charcoal, manure, and crop residues) for household heating and cooking (International Energy Agency, 2014). This is observed in Figure 1, which shows that there has been an increasing discrepancy between electricity production and consumption in Mozambique since 1997. With the discovery of more energy resources, there has been increased production of electricity over the years. However, on the consumption side, there has been a much slower migration from the use of biomass to electricity, because a significant proportion of the population living in rural communities are dispersed throughout the provinces, with limited or no access to the national grid. Currently, the majority of the electricity produced in Mozambique is exported – mainly to South Africa and Zimbabwe.



Source: Own computations using data from the World Bank (2014).

Fig. 1. Trends in electricity consumption and production (KwH, 1990-2011)

The energy sector in Mozambique has, however, changed significantly in recent years – since the discovery of natural gas and coal resources. Recent discoveries of these resources have provided a stimulus to the energy sector; and this is now promising to play a significant role in driving economic growth. The International Monetary Fund (IMF) estimates that coal and natural gas production could potentially increase Mozambique's annual economic growth rate by 2% during the 2013-23 period.

The availability of cheap electricity is one of the main reasons for the significant foreign direct investment in energy-intensive industries in the country. Mozambique's natural gas reserves, at the beginning of 2014 were approximately 100 trillion cubic feet (Tcf), an increase from 4.5 Tcf in 2013 (see International Energy Agency, 2014). This makes the country the third largest natural gas reserve holder in Africa, after Nigeria and Algeria.

In addition, Mozambique is now the second largest coal producer in Africa (behind South Africa), having surpassed Zimbabwe in 2012. The total coal reserves are estimated to be in the region of 3 billion short tons. Coal production increased to approximately 5.4 million short tons in 2012 – an increase from 42,000 short tons in 2010 (International Energy Agency, 2014). Of the total coal produced in 2012, approximately 3.3 million short tons were exported to Asia and South Africa; while only 80,000 short tons were consumed domestically.

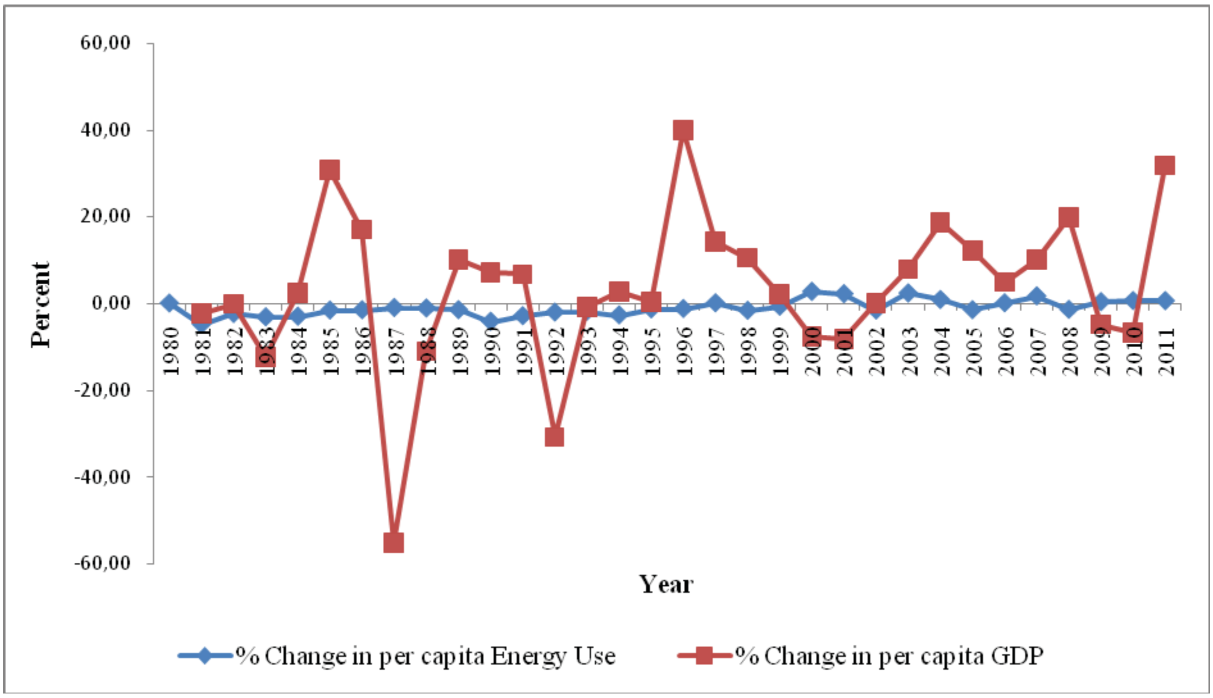
However, the country is currently faced with limitations in its energy production capacity. For instance, only 154 billion cubic feet (Bcf) of natural gas were produced in 2012. The majority of the gas (about 127 Bcf) was exported to South Africa through the Sasol Petroleum International Gas Pipeline. In addition, there are limitations in the railway system's capacity to transport coal exports from the in-land mines to the coast; and this has, in turn, seriously hindered coal exports.

To address these shortcomings, the country has embarked on several infrastructural projects to boost its energy production capacity. For example, there is the Mphanda Nkuwa hydropower plant, which is currently under construction. It is expected to have a production capacity of about 1,500 MW; and the Cabora Bassa North Bank Dam – with a planned capacity of 1245 MW, among other projects.

Furthermore, there are plans to develop two on-shore 240 Bcf liquefied natural gas (LNG) trains – in a joint project by two companies (one from America, the other from Italy) that are leading the exploration activities in Mozambique's offshore Rovuma Basin. In addition, there are plans to build a 100-MW natural gas-fired power station in Maputo by 2018.

In the coal sector, there are plans to increase the cargo capacity of the Sena railway – from about 6.6 million to 22 million short tons annually by 2015. In addition, a new railway line, the Nacala Rail Corridor, is scheduled to be completed by the end of 2014 – with exports expected to commence at the beginning of 2015 (International Energy Agency, 2014). Furthermore, there are plans to build a larger coal-fired power station next to the Ncondezi coal mine, which is expected to eventually have the capacity to produce 1,800 MW of electricity. There are more power plants linked to the Moatize mines, with a planned capacity of 2400 MW. Lastly, plans are underway to build a power transmission "backbone" that will transmit electricity from the central region, where it is mainly produced, to the rest of the country. This will improve access to electricity by an increased proportion of the population.

Figure 2 shows an overview of the trends in *per capita* energy consumption and GDP growth in Mozambique for the period of 1981-2011. The GDP has been fluctuating over the past three decades, with a number of periods in which there were negative growth rates. Changes in *per capita* GDP averaged 2.19% in the 1980s, but increased to an average rate of 5.32% and 6.63% in the 1990s and 2000s, respectively. On the other hand, *per capita* energy consumption has remained relatively low over the years, with changes in consumption averaging at -1.91% per individual in the 1980s, and -1.75% in the 1990s. The 2000s showed a slight improvement in consumption, with increases in consumption averaging at 0.72% per individual.



Source: Own computations using data from the World Bank (2014).

Fig. 2. Trends in per capita energy consumption and economic growth (1981-2011)

2. Literature review

There are generally four hypotheses regarding the causal relationship between energy and economic growth, and the resultant policy implications that have been advanced in the economic literature. The first hypothesis, the "growth" hypothesis, asserts that increases in energy consumption lead to increases in real output growth. The theory implies that economic growth is dependent on energy consumption, both directly and indirectly in the production process, as a complement to labor and capital. As such, any energy conservation-oriented policies implemented in an economy, where such a relationship holds, could have adverse effects on economic growth (Odhiambo, 2009; Ozturk, 2010; Payne, 2008).

The second hypothesis, the "conservation" hypothesis, on the other hand, stipulates that increases in real GDP lead to increases in energy consumption in an economy. The theory implies that the demand for energy is driven largely by the growth in the real sector in an otherwise low energy-dependent economy. Consequently, energy conservation policies aimed at reducing energy consumption and waste could be implemented – with little or no adverse effects on real GDP (Odhiambo, 2009; Ozturk, 2010; Payne, 2008).

The third theory, the "neutrality hypothesis", asserts that energy consumption does not have any significant impact on economic growth, because it comprizes a small component of real GDP. Thus, neither conservative nor expansive energy consumption policies would have any effect on economic growth (Ozturk, 2010; Payne, 2008). Lastly, the "feedback hypothesis", stipulates that there is bidirectional causality between energy consumption and economic growth (Payne, 2008).

Empirical studies that focus on examining the energy-growth nexus are vast, and have produced varying opinions on the direction of causality between energy (electricity) and economic growth. Some studies found in favor of the "growth" hypothesis. These include those of Odhiambo (2014; 2010; 2009), Ouedraogo (2013), Al-mulali and Sab (2012), Apergis and Payne (2010), Pao and Tsai (2010), Tsani (2010), Wolde-Rufael (2009; 2006), Narayan and Prasad (2008), Mahadevan and Asafu-Adjaye (2007), Asafu-Adjaye (2000), and, Masih and Masih (1997).

Other studies found in favor of the "conservation" hypothesis. These include those of Ouedraogo (2013), Sharma and Bruce (2013), Stern and Enflo (2013), Odhiambo (2010), Wolde-Rufael (2009; 2006), Zhang and Cheng (2009), Akinlo (2008), Jumbe (2004), Masih and Masih (1997), and Kraft and Kraft (1978).

Studies in favor of the "feedback" hypothesis include those of: Stern and Enflo (2013), Dagher and Yacoubian (2012), Fowowe (2012), Fuinhas and Marques (2012), Wesseh and Zoumara (2012), Zhang (2011), Pao and Tsai (2010), Wolde-Rufael (2009; 2006), Mahadevan and Asafu-Adjaye (2007), Akinlo (2008), Ghali and El-Sakka (2004), Jumbe (2004), and Asafu-Adjaye (2000).

Lastly, some studies found in favor of the "neutrality" hypothesis. These include those of Ozturk and Acaravci (2011), Ozturk and Acaravci (2010), Wolde-Rufael (2009; 2006), Narayan and Prasad (2008), Akinlo (2006), and Masih and Masih (1997).

A number of the studies on developing countries have relied on cross-sectional analyses. These include studies by Ouedraogo (2013), Al-mulali and Sab (2012), Apergis and Payne (2010), Fowowe (2012), and Huang et al. (2008). However, the literature reveals that cross-sectional methods of analysis fail to address explicitly the potential biases induced by the existence of cross-country heterogeneity, which may lead to inconsistent and misleading estimates (Odhiambo, 2011, 2009; Casselli et al., 1996; Quah, 1993).

The recently developed ARDL-bounds testing approach is favored over conventional cointegration techniques, such as the Engle-Granger (1987), the Johansen (1991 and 1995) maximum-likelihood based, and the Johansen-Juselius (1990) tests in country-specific studies. This is because the conventional techniques have been criticized for their low testing power, among other problems. The ARDL technique is more robust; and it provides better results for small sample data sets (such as that of the current study) than the conventional techniques (Haug, 2002).

Furthermore, the ARDL technique can be applied, regardless of whether the underlying regressors are purely I(0), purely I(1) or mutually cointegrated. In addition, the dynamic error-correction model integrates the short-run dynamics with the long-run equilibrium, without losing long-run information (Banerjee et al., 1993). Table 1 gives a summary of the previous empirical studies conducted on the energy-growth nexus.

Table 1. Summary of empirical studies conducted on the energy-growth nexus

Author(s)	Country (period)	Methodology	Causality relationship
1. Studies in favor of the "growth" hypothesis			
Odhiambo (2014)	Ghana, Cote d'Ivoire, Brazil and Uruguay (1972-2006)	ARDL-Bounds testing approach	EC→GDP in Brazil and Uruguay
Ouedraogo (2013)	15 ECOWAS Countries (1980-2008)	Panel cointegration and causality tests	EC→GDP in the long run
Al-mulali and Sab (2012)	30 Sub-Saharan African countries (1980-2008)	Panel cointegration and causality tests	EC→GDP
Apergis and Payne (2010)	9 South American countries (1980–2005)	Panel cointegration and error correction model	EC→GDP
Odhiambo (2010)	The DRC, Kenya and South Africa (1972–2006)	ARDL Bounds testing approach	EC→Economic growth in South Africa and Kenya
Pao and Tsai (2010)	Brazil, Russia, India and China	Granger Causality	EC→GDP

Table 1 (cont.). Summary of empirical studies conducted on the energy-growth nexus

Author(s)	Country (period)	Methodology	Causality relationship
1. Studies in favor of the “growth” hypothesis			
Tsani (2010)	Greece (1960-2006)	Causality tests	EC→GDP
Belloumi (2009)	Tunisia (1971-2004)	Vector error correction model	EC→ GDP in the short run
Odhiambo (2009)	Tanzania	ARDL bounds testing approach	EC→GDP
Wolde-Rufael (2009)	17 African countries (1971-2004)	Multivariate Granger causality	EC→GDP in Algeria, Benin and South Africa
Narayan and Prasad (2008)	30 OECD countries	Bootstrapped causality tests	Electricity consumption →GDP in Australia, Iceland, Italy, the Slovak Republic, the Czech Republic, Korea, Portugal and the UK
Mahadevan and Asafu-Adjaye (2007)	20 net energy importers and exporters (1971-2002)	Panel error-correction model	EC→GDP in Argentina, Indonesia, Kuwait, Malaysia, Nigeria, Saudi Arabia and Venezuela
Wolde-Rufael (2006)	17 African countries (1971-2001)	ARDL bounds-testing approach	EC→GDP in Benin, DRC, Tunisia
Asafu-Adjaye (2000)	India, Indonesia, the Philippines and Thailand (varying periods)	Vector error-correction model	EC→ Income in India and Indonesia
Masih and Masih (1997)	India, Indonesia, Pakistan, Malaysia, Singapore and the Philippines (varying periods)	Vector error-correction model	Electricity consumption→ GDP in India
2. Studies in favor of the “conservation” hypothesis			
Odhiambo (2014)	Ghana, Cote d’Ivoire, Brazil and Uruguay (1972-2006)	ARDL-bounds testing approach	GDP→EC in Ghana and Côte d' Ivoire
Sharma and Bruce (2013)	USA	Multivariate VECM	GDP→EC
Stern and Enflo (2013)	Sweden (1850-2000)	Granger causality and co-integration techniques	GDP→EC in recent smaller samples
Ouedraogo (2013)	15 ECOWAS countries (1980-2008)	Panel cointegration and causality tests	GDP→EC in the short run
Odhiambo(2010)	The DRC, Kenya and South Africa (1972–2006)	ARDL bounds-testing approach	Economic growth→ EC in the DRC
Wolde-Rufael (2009)	17 African countries (1971-2004)	Multivariate Granger causality	GDP→EC in Egypt, Ivory Coast, Morocco, Nigeria, Senegal, Sudan, Tunisia and Zambia
Zhang and Cheng (2009)	China (1960-2007)	Toda and Yamamoto (1995) Granger causality test and generalized impulse response	GDP→EC
Akinlo (2008)	11 Sub-Sahara African countries	ARDL Bounds testing approach	GDP→EC in Sudan and Zimbabwe
Huang et al. (2008)	82 countries (1972-2002)	Panel VAR model	GDP→EC (positively) in lower and upper middle income countries GDP→EC (negatively) in high income countries
Wolde-Rufael (2006)	17 African countries (1971-2001)	ARDL bounds testing approach	Economic Growth→ Electricity Consumption in Cameroon, Ghana, Nigeria, Senegal, Zambia and Zimbabwe
Jumbe (2004)	Malawi (1970-1999)	Vector error correction model	GDP→ Electricity Consumption
Masih and Masih (1997)	India, Indonesia, Pakistan, Malaysia, Singapore and the Philippines (varying periods)	Vector error correction model	GDP→Electricity consumption in Indonesia and Pakistan
Kraft and Kraft (1978)	USA (1947-1974)	Granger causality	GNP→EC
3. Studies in favor of the “feedback” hypothesis			
Stern and Enflo (2013)	Sweden (1850-2000)	Granger causality and co-integration tests	EC↔GDP in the full sample
Dagher and Yacoubian (2012)	Lebanon (1980-2009)	Causality tests	EC↔GDP
Fowowe (2012)	14 Sub-Saharan African (1971-2004)	Panel cointegration tests	EC↔GDP
Fuinhas and Marques (2012)	Portugal, Italy, Greece, Spain and Turkey (1965-2009)	ARDL Bounds-testing approach	EC↔GDP
Wesseh and Zoumara (2012)	Liberia (1980-2008)	Bootstrapped causality test	EC↔ GDP
Zhang (2011)	Russia (1970-2008)	Granger causality	EC↔ GDP
Pao and Tsai (2010)	Brazil, Russia, India and China	Granger causality	EC↔GDP in the long run
Belloumi (2009)	Tunisia (1971-2004)	Vector error-correction model	EC↔GDP in the long run

Table 1 (cont.). Summary of empirical studies conducted on the energy-growth nexus

Author(s)	Country (period)	Methodology	Causality relationship
3. Studies in favor of the "feedback" hypothesis			
Wolde-Rufael (2009)	17 African countries (1971-2004)	Multivariate granger causality	EC↔GDP in Gabon, Ghana, Togo and Zimbabwe
Mahadevan, and Asafu-Adjaye (2007)	20 net energy importers and exporters (1971-2002)	Panel error-correction model	EC↔GDP in Australia, Norway, UK, Japan, Sweden and USA
Akinlo (2008)	11 Sub-Saharan African countries	ARDL bounds-testing approach	EC↔GDP in Gambia, Ghana and Senegal
Wolde-Rufael (2006)	17 African countries (1971-2001)	ARDL bounds-testing approach	EC↔GDP in Egypt, Gabon, Morocco
Ghali and El-Sakka (2004)	Canada (1961-1997)	Vector error-correction model	EC↔GDP
Jumbe (2004)	Malawi (1970-1999)	Granger causality	EC↔GDP
Asafu-Adjaye (2000)	India, Indonesia, the Philippines and Thailand (varying periods)	Vector error-correction model	EC↔Income in Thailand and the Philippines
4. Studies in favor of the "neutrality" hypothesis			
Ozturk and Acaravci (2011)	11 Middle East and North Africa (MENA) countries (1971-2006)	ARDL bounds-testing approach	EC---GDP in all the sample countries
Ozturk and Acaravci (2010)	Turkey (1968–2005)	ARDL bounds-testing approach	EC---GDP
Wolde-Rufael (2009)	17 African countries (1971-2004)	Multivariate Granger causality	EC---GDP in Cameroon and Kenya
Huang et al., 2008	82 countries (1972-2002)	Panel VAR model	EC---GDP for Low-income Countries
Narayan and Prasad (2008)	30 OECD countries	Bootstrapped causality tests	EC---GDP in Austria, Belgium, Canada, Denmark, Finland, France, Germany, Greece, Hungary, Ireland, Japan, Luxembourg, Mexico, Netherlands, New Zealand, Norway, Poland, Slovak Rep., Spain, Sweden, Switzerland, Turkey and the USA
Akinlo (2006)	11 Sub-Saharan African countries	ARDL bounds testing approach	EC---GDP in Cameroon, Cote D'Ivoire, Nigeria, Kenya and Togo
Wolde-Rufael (2006)	17 African countries (1971-2001)	ARDL bounds-testing approach	EC---GDP in Algeria, Congo, Kenya, South Africa, Sudan
Masih and Masih (1997)	India, Indonesia, Pakistan, Malaysia, Singapore and the Philippines (varying periods)	Vector error-correction model	EC---GDP in Malaysia, Singapore and the Philippines

Note: EC→GDP means that there is unidirectional causality from energy consumption to growth. GDP→EC means there is unidirectional causality from growth to energy consumption. EC↔ GDP means that there is bidirectional causality between energy consumption and growth. EC–GDP means that there is no causality between energy consumption and growth. Abbreviations are defined as follows: EC = energy consumption, GDP = real gross domestic product.

3. Estimation techniques and empirical analysis

3.1. Cointegration model – the ARDL-bounds testing procedure. In this paper, we use the recently developed ARDL-bounds testing approach – based on Perasan and Shin (1999) and Perasan et al. (2001) – to examine the long-run relationship between energy consumption and economic growth in Mozambique. The ARDL model used in this study can be expressed as follows (see also Odhiambo, 2009):

$$\Delta Growth_t = a_0 + \sum_{i=1}^{n} a_{1i}\Delta Growth_{t-i} + \sum_{i=0}^{n} a_{2i}\Delta Energy_{t-i} + a_3 Growth_{t-1} + a_4 Energy_{t-1} + \mu_{t1}, \quad (1)$$

$$\Delta Energy_t = \beta_0 + \sum_{i=1}^{n} \beta_{1i}\Delta Energy_{t-i} + \sum_{i=0}^{n} \beta_{2i}\Delta Growth_{t-i} + \beta_3 Energy_{t-1} + \beta_4 Growth_{t-1} + \mu_{t2}. \quad (2)$$

where: Growth = Economic growth (measured by GDP per capita); Energy = Energy consumption; μ_t = white noise-error term; Δ = first difference operator.

The data used in this study are annual time-series data from 1980 to 2011. The data were obtained from the World Bank's databank (previously known as the World Development Indicators Online). The ARDL-bounds test involves two steps. In the first step, the Schwartz-Bayesian Criterion (SBC) is used to determine the order of lags of the differenced variables included in both energy and economic growth equations. As the optimal lag has been determined, the next step is to apply the bounds F-test to equations (1) and (2), in order to establish a co-integration relationship between energy consumption and economic growth.

3.2. The ECM-based granger causality model. The causality model can be expressed as follows:

$$\Delta Growth_t = \delta_0 + \sum_{i=1}^{n} \delta_{1i} \Delta Growth_{t-i} + \sum_{i=1}^{n} \delta_{2i} \Delta Energy_{t-i} + \delta_3 ECM_{t-1} + v_{1i}, \quad (3)$$

$$\Delta Energy_t = \lambda_0 + \sum_{i=1}^{n} \lambda_{1i} \Delta Energy_{t-i} + \sum_{i=1}^{n} \lambda_{2i} \Delta Growth_{t-i} + \lambda_3 ECM_{t-1} + v_{2i}. \quad (4)$$

Where: ECM_{t-1} is the error-correction term lagged one period; and V_{1t} and V_{2t} are mutually uncorrelated white-noise residuals. Based on equations (3) and (4), the "short-run" causal effects between energy consumption and economic growth are determined by using the F-statistics; while the "long-run" causal relationships are determined by the coefficients of the error-correction terms (see also Odhiambo, 2010).

3.3. Empirical analysis. *3.3.1. Stationarity tests.* Although the ARDL-bounds testing approach to co-integration does not require variables to be integrated of the same order, it is important to test for the unit root – because the technique cannot be used when the variables in the equation are integrated of order two (2), or higher. In other words, for the ARDL-bounds test to be correctly used, all the variables in this study must be integrated of order zero [I(0)], or integrated of order one [I(1)], or fractionally integrated of both order zero and order one. In this study, we use three unit-root tests, in order to examine the order of integration. These include the ADF test, the PP test, and the Ng-Perron test. The results of the stationarity tests in levels and on difference are reported in Tables 2 and 3.

Table 2. Stationarity tests of variables – ADF and Dickey-Fuller-GLS tests

Variable	ADF (without Trend)		ADF (with trend)		Dickey-Fuller-GLS (without trend)		Dickey-Fuller-GLS (with trend)	
	Level	1st diff	Level	1st diff	Level	1st diff	Level	1st diff
Energy	-1.58	-3.52**	-1.34	-4.91***	-0.89	-2.55**	-1.20	-4.79***
Growth	1.03	-3.18**	-1.70	-3.77**	-0.17	-3.23***	-1.77	-3.79***

Note: 1) The truncation lag for the PP tests is based on Newey and West (1987) band width. 2) Critical values for Dickey-Fuller GLS test are based on Elliot-Rothenberg-Stock (1996, Table 1). 3) ** and *** denote 5% and 1% level of significance, respectively.

Table 3. Stationarity tests of variables –Ng-Perron test

Variable	Ng-Perron test (levels, without trend)				Ng-Perron test (level, with trend)			
	MZ	MZt	MSB	MPT	MZ	MZt	MSB	MPT
Energy	0.15	0.22	1.46	115.04	0.43	0.34	0.78	133.76
Growth	0.66	0.41	0.62	29.45	-0.53	-0.36	0.67	88.96
Variable	Ng-Perron Test (1st diff, without trend)				Ng-Perron test (1st diff, with trend)			
	MZ	MZt	MSB	MPT	MZ	MZt	MSB	MPT
Energy	-6.59*	-1.71*	0.26*	4.06*	-15.12*	-2.74*	0.18*	6.08*
Growth	-11.69**	-2.41**	0.21**	2.11**	-15.65*	-2.79*	0.17*	5.82*

Note: * and ** denote 5% and 10% level of significance, respectively.

As shown in Tables 2 and 3, both energy consumption and economic growth variables were found to be non-stationary in levels. The three unit-root tests used in this analysis, namely ADF, PP and Ng-Perron tests, have all rejected the stationarity of these two variables in levels. This implies that the variables are not integrated of order zero [i.e. I(0)]. The variables were then differenced once, before stationarity tests were performed again. It was found that after differencing, both energy consumption and economic growth were stationary. This, therefore, implies that the variables are integrated of order one [i.e. I (1)].

3.3.2. Cointegration analysis – the ARDL-bounds-testing procedure. The results of the ARDL-bounds test are reported in Table 4.

Table 4. Bounds F-test for cointegration

Dependent variable	Function				F-test statistic	
Growth	Growth (Energy)				4.6799**	
Energy	Energy (Growth)				1.0386	
Asymptotic critical values						
	1 %		5%		10%	
	I(0)	I(1)	I(0)	I(1)	I(0)	I(1)
Pesaran et al. (2001), p. 300, Table CI(ii) Case II	4.94	5.58	3.62	4.16	3.02	3.51

Note: ** denotes statistical significance at the 5% level.

According to Pesaran and Pesaran (1997), and Pesaran et al. (2001), there are two sets of critical values for any given significance level. The first set of critical values assumes that all the variables included in the ARDL model are I(0); while the second set of critical values assumes that the variables are I(1). Based on the results reported in Table 4, we may conclude that there is a cointegration relationship between energy consumption and economic growth, when growth (y/N) is used as the dependent variable. This finding is confirmed by the calculated F-statistic in the economic growth equation, which is found to be higher than the upper bound critical value reported in Pesaran et al. (2001) at the 5% level. Consequently, we may conclude that there is a long-run relationship between energy consumption and economic growth.

3.3.3. The ECM-based Granger causality test. Having confirmed the existence of a long-run relationship between energy consumption and economic growth in the preceding section, we can now proceed to test for the Granger-causality between these two variables, using the error-correction mechanism. The results of our ECM-based causality test are reported in Table 5.

Table 5. Granger non-causality test

Dependent variable	Causal flow	F-statistics [P-value]		ECM [*t* - statistic]
		Growth (y/N)	Energy consumption	
Growth (y/N)	Energy consumption→Growth	-	5.61*** (0.0104)	-0.10 -2.1829]**
Energy (ENG)	Growth→Energy consumption	0.180 (0.8370)	-	-

Note: ** and *** denote statistical significance at the 5% and 1% levels, respectively.

The results of the causality test, as reported in Table 5, show that there is a distinct causal flow from energy consumption to economic growth in Mozambique. This applies both in the short run and in the long run. As reported in Table 5, the short-run causal flow is confirmed by the F-statistic, which is statistically significant in the economic growth equation, but not in the energy consumption equation. The long-run causal flow, on the other hand, is confirmed by the coefficient of the ECM, which was found to be negative and statistically significant, as expected. These results show that for Mozambique, it is energy consumption, which drives economic growth, and not vice versa.

Conclusion

This paper aims to examine the causal relationship between energy consumption and economic growth in Mozambique during the period of 1980-2011. Despite numerous studies that have been conducted on this subject, there is still no consensus as to whether energy consumption drives economic growth; or whether it is the real sector that drives energy consumption. Unlike some of the previous studies, the current study has used the recently developed ARDL-bounds testing approach to cointegration and the ECM-based Granger causality method to examine this linkage. To the best of our knowledge, this might be the first study of its kind to examine the causal relationship between energy consumption and economic growth in Mozambique – using modern time-series techniques. The empirical findings of our study show that there is a long-run relationship between energy consumption and economic growth in Mozambique. The results also show that there is a distinct unidirectional causality from energy consumption to economic growth. This implies that for Mozambique, it is the consumption of energy that drives development in the real sector, and not vice versa. This finding applies both in the short run and in the long run. Our study, therefore, concludes that a rapid expansion of the energy infrastructure is required in Mozambique, in order to enable the country to cope with the expected future increase in energy demand.

References

1. Akinlo, A.E. (2008). Energy Consumption and Economic Growth: Evidence from 11 Sub-Sahara African Countries, *Energy Economics*, 30, pp. 2391-2400.
2. Al-mulali, U. and 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, pp. 180-186.
3. Apergis, N. and Payne, J.E. (2010). Energy Consumption and Growth in South America: Evidence from a Panel Error Correction Model, *Energy Economics*, 32, pp. 1421-1426.
4. Asafu-Adjaye, J. (2000). The Relationship between Energy Consumption, Energy Prices and Economic Growth: Time Series Evidence from Asian Developing Countries, *Energy Economics*, 22, pp. 615-625.
5. Banerjee A., Dolado, J.J., Galbraith, J.W. and Hendry, D.F. (1993). *Co-integration, Error Correction, and the Econometric Analysis of Non-stationary Data*. Oxford, Oxford University Press.
6. Belloumi, M. (2009). Energy Consumption and GDP in Tunisia: Cointegration and Causality Analysis, *Energy Policy*, 37, pp. 2745-2753.

7. Caselli, F., Esquivel, G. and Lefort, F. (1996). Reopening the Convergence Debate: A New Look at Cross-Country Growth Empirics, *Journal of Economic Growth*, 1, pp. 363-389.
8. Chen, S.-T., Kuo, H.-I., Chen, C.-C. (2007). The Relationship between GDP and Electricity Consumption in 10 Asian Countries, *Energy Policy*, 35, pp. 2611-2621.
9. Dagher, L. and Yacoubian, T. (2012). The Causal Relationship between Energy Consumption and Economic Growth in Lebanon, *Energy Policy*, 50, pp. 795-801.
10. Elliott, G., Rothenberg, T.J. and Stock, J.H. (1996). Efficient Tests for an Autoregressive Unit Root, *Econometrica*, 64 (4), pp. 813-836.
11. Fagbenle, R.O. (2001). National renewable energy policy objectives and programmes in Botswana, *Renewable Energy*, 24 (3-4), pp. 419-437.
12. Fuinhas, J.A. and Marques, A.C. (2012). Energy Consumption and Economic Growth Nexus in Portugal, Italy, Greece, Spain and Turkey: An ARDL Bounds Test Approach (1965-2009), *Energy Economics*, 34, pp. 511-517.
13. Fowowe, B. (2012). Energy Consumption and Real GDP: Panel Co-Integration and Causality Tests for Sub-Saharan African Countries. *Journal of Energy in Southern Africa*, 23 (1), pp. 8-14.
14. Ghali, K. H. and El-Sakka, M.I.T. (2004). Energy Use and Output Growth in Canada: A Multivariate Cointegration Analysis, *Energy Economics*, 26, pp. 225-238.
15. Haug, A.A. (2002). Temporal Aggregation and the Power of Cointegration Tests: a Monte Carlo Study, *Oxford Bulletin of Economics and Statistics*, 64, pp. 399-412.
16. Huang, B-N., Hwang, M.J. and Yang, C.W. (2008). Causal Relationship between Energy Consumption and GDP Growth Revisited: A Dynamic Panel Data Approach, *Ecological Economics*, 6 (7), pp. 41-54.
17. International Energy Agency (2014). *World Energy Outlook*. Paris: International Energy Agency.
18. Jumbe, C.B.L. (2004). Cointegration and Causality between Electricity Consumption and GDP: Empirical Evidence from Malawi, *Energy Economics*, 26, pp. 61-68.
19. Karanfil, F. (2008). Energy Consumption and Economic Growth Revisited: Does the Size of Unrecorded Economy Matter? *Energy Policy*, 36 (8), pp. 3029-3035.
20. Kraft, J. and Kraft, A. (1978). On the Relationship between Energy and GNP, *Journal of Energy and Development*, 3, pp. 401-403.
21. Mahadevan, R. and Asafu-Adjaye, J. (2007). Energy Consumption, Economic Growth and Prices: A Reassessment Using Panel VECM for Developed and Developing Countries, *Energy Policy*, 35, pp. 2481-2490.
22. Ministry of Energy (2013). Country Report presented by the Ministry of Energy of Mozambique. Tokyo, Japan.
23. Masih, A.M.M. and Masih, R. (1997). On the Temporal Causal Relationship between Energy Consumption, Real Income Prices: Some New Evidence from Asian NICs Based on Multivariate Cointegration/Vector Error Correction Approach, *Journal of Policy Modelling*, 19, pp. 417-440.
24. Narayan, P.K. and Prasad, A. (2008). Electricity Consumption – Real GDP Causality Nexus: Evidence from a Bootstrapped Causality Test for 30 OECD Countries, *Energy Policy*, 36, pp. 910-918.
25. Newey, W.K. and West, K.D. (1987). A Simple, Positive Semi-Definite, Heteroskedasticity and Autocorrelation Consistent Covariance Matrix, *Econometrica*, 55, pp. 703-708.
26. Odhiambo, N.M. (2014). Energy Dependence in Developing Countries: Does the Level of Income Matter? *Atlantic Economic Journal*, 42, pp. 65-77.
27. Odhiambo, N.M. (2011). Growth, Employment and Poverty in South Africa: In Search of a Trickle-Down Effect, *Journal of Income Distribution*, 20 (1), pp. 49-62.
28. Odhiambo, N.M. (2010). Energy Consumption, Prices and Economic Growth in Three SSA Countries: A Comparative Study, *Energy Policy*, 38, pp. 2463-2469.
29. Odhiambo, N.M. (2009). Energy Consumption and Economic Growth in Tanzania: An ARDL Bounds Testing Approach, *Energy Policy*, 37 (2), pp. 617-622.
30. Ouedraogo, N.S. (2013). Energy Consumption and Economic Growth: Evidence from the Economic Community of West African States (ECOWAS), *Energy Economics*, 36, pp. 637-647.
31. Ozturk, I. (2010). A Literature Survey on Energy – Growth Nexus, *Energy Policy*, 38, pp. 340-349.
32. Ozturk, I. and Acaravci, A. (2011). Electricity Consumption and Real GDP Causality Nexus: Evidence from ARDL Bounds Testing Approach for 11 MENA Countries, *Applied Energy*, 88, pp. 2885-2892.
33. Ozturk, I. and Acaravci, A. (2010). CO_2 Emissions, Energy Consumption and Economic Growth in Turkey, *Renewable and Sustainable Energy Reviews*, 14, pp. 3220-3225.
34. Pao, H.-T. and Tsai, C.-M. (2010). CO_2 Emissions, Energy Consumption and Economic Growth in BRIC Countries, *Energy Policy*, 38, pp. 7850-7860.
35. Payne, J.E. (2008). Survey of the International Evidence on the Causal Relationship between Energy Consumption and Growth, *Journal of Economic Studies*, 37 (1), pp. 53-95.
36. Pesaran, M.H. and Pesaran B. (1997). *Working with Microfit 4.0: Interactive Econometric Analysis*. Oxford, Oxford University Press.
37. Pesaran, M.H. and Shin, Y. (1999). An Autoregressive Distributed Lag Modelling Approach to Co-integration Analysis. In S. Strom, A. Holly and P. Diamond (Eds.), *Econometrics and Economic Theory in the 20th Century: The Ragner Frisch Centennial Symposium*. Cambridge, Cambridge University Press.

38. Pesaran, M.H., Shin, Y. and Smith, R. (2001). Bounds Testing Approaches to the Analysis of Level Relationships, *Journal of Applied Econometrics*, 16, pp. 289-326.
39. Quah, D. (1993). Empirical Cross-Section Dynamics in Economic Growth, *European Economic Review*, 37, pp. 2-3.
40. Sharma, A. and Bruce, C. (2013). The Relationship between Energy and U.S. GDP: A Multivariate Vector Error Correction Model, *Journal of Energy and Development*, 38 (1) and (2), pp. 1-17.
41. Stern, D.I. and Enflo, K. (2013). Causality between Energy and Output in the Long-Run, *Energy Economics*, 39, pp. 135-146.
42. Tsani, S.Z. (2010). Energy Consumption and Economic Growth: A Causality Analysis for Greece, *Energy Economics*, 32, pp. 582-590.
43. Wesseh, P.K. and Zoumara, B. (2012). Causal Independence between Energy Consumption and Economic Growth in Liberia: Evidence from a Non-Parametric Bootstrapped Causality Test, *Energy Policy*, 50, pp. 518-527.
44. Wolde-Rufael, Y. (2009). Energy Consumption and Economic Growth: The Experience of African Countries Revisited, *Energy Economics*, 31, pp. 217-224.
45. Wolde-Rufael, Y. (2006). Electricity Consumption and Economic Growth: A Time Series Experience for 17 African countries. *Energy Policy*, 34, pp. 1106-1114.
46. World Bank (2014). *World Development Indicators 2014*, Washington, D.C.: World Bank.
47. Zhang, Y.-J. (2011). Interpreting the Dynamic Nexus between Energy Consumption and Economic Growth: Empirical Evidence from Russia, *Energy Policy*, 39, pp. 2265-2272.
48. Zhang, X.-P. and Cheng, X.-M. (2009). Energy Consumption, Carbon Emissions, and Economic Growth in China, *Ecological Economics*, 68, pp. 2706-2712.
49. Taylor et al., G. Grugulis, I. and Stoyanova, D. (2003). Skill and Performance, *British Journal of Industrial Relations*, 49 (3), pp. 515-536.
50. Thom, I. (2007). Teaching Hard, Teaching Soft; a structured approach to planning and running effective training courses. Aldershot: Gower.
51. Tien, C.L., Ven, U. and Chou, B.K. (2003). Critical skills of IS professionals: A model for curriculum development, *Journal of Information Technology Education*, Vol. 1, No. 3, pp. 143-154.
52. Todd, K., Gallivan, M., Truex, D., III & Kvasny, L. (2005). Changing patterns in IT skill sets 1998-2003: A content analysis of classified advertising, *Database for Advances in Information Systems*, 35, pp. 64-86.
53. Velde, I. (2004). The hard facts about soft skills measurement, *Training Journal*, August, pp. 53-56.
54. Wilhelm, A. (2004). Soft skills, hard truths, *Training*, Vol. 42, No. 7, pp. 18-22.
55. Wood, R. and Payne, N. (1998). A Manager's Guide to Self-Development, 2nd edition, McGraw-Hill, Maidenhead, Berkshire.
56. World Bank (2008). Working it Out at Work. Washington D.C: Sherwood Publishing.
57. Yost, D. (2002). Student and employer perceptions of desirable entry-level operations management skills, *American Journal of Business*, (16) 1, pp. 50-59.