Trivariate Causality between Economic Growth, Urbanisation and Electricity Consumption in Angola: Cointegration and Causality Analysis

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Abstract

This paper investigates the causal relationship between economic growth, urbanisation and electricity consumption in the case of Angola, utilizing the data over the period of 1971-2009. We have applied Lee and Strazicich (2003, 2004) unit root test to test the stationarity properties of the series. Gregory-Hansen structural break cointegration procedure as complement, we employed the ARDL bounds test to examine long run relationship. The VECM Granger causality test is subsequently used to examine the direction of causality between economic growth, urbanisation and electricity consumption. Our results indicate the existence of long run relationship. We further observe evidence in favour of bidirectional causality between electricity consumption and economic growth. The feedback hypothesis is also found between urbanization and economic growth. Urbanization and electricity consumption Granger cause each other. We conclude that Angola is an energy (electricity) dependent country. Consequently, the relevant authorities should boost electricity production as one of the means of achieving sustainable economic development for long span of time.

Keywords: Electricity; Growth; Urbanisation
JEL Classification: Q43, O55

Introduction

Energy is increasingly becoming a major force in the pursuit of sustainable development. The attribute of neutrality ascribed to energy by neoclassical model is becoming more contestable as consistent growing sources of modern energy could directly aid livelihoods, and indirectly via promotion of economic growth (IEA, 2006). As a principal source of energy, accessibility to electricity aids the process of meeting residential and domestic needs; positively contributes to capital and labour productivity; promotes export potentials of countries (Narayan and Smyth, 2009); creates employment (Narayan and Smyth, 2005) and decreases the poverty level; and ultimately improves socio-economic development (Poveda and Martínez, 2011). Countries' level of development appears to be associated with intensity of electricity usage as only 24.84% of the population in least developed countries enjoys electricity, while about 81.41% of the population in middle income countries had access to electricity in the year 2009. In the same year, electricity consumption in European Union was 11-fold of the total consumption in Sub-Saharan Africa, in spite of the African countries having a larger population (World Bank, 2011).

Recognizing the importance of electricity in economic development agenda, there has been upsurge of empirical literatures to verify the true connection of electricity consumption and economic activity in different countries and regions. Causality tests are recurrently employed in existing energy papers to determine the relationship between electricity consumption and economic growth. The causality running from electricity consumption towards economic growth infers that electricity influences economic growth and thus electricity expansionary is compatible with improvement of economic performance of the country. The causality running from economic growth to electricity consumption implies that economic growth is not dependent on electricity usage and therefore, conservation policies should be pursued.

The feedback hypothesis between electricity consumption and economic growth means both variables are interrelated, supporting expansionary policies. Neutral hypothesis between economic growth and electricity consumption suggests the limited role of electricity consumption for economic growth[1].

Empirical studies on causal relationship between electricity consumption and economic growth are wide-ranging with inconsistent results (see Aqeel and Butt, 2001; Yoo, 2005; Yoo, 2006; Chen et al. 2007; Ho and Siu, 2007; Hu and Lin, 2008; Jamil and Ahmad, 2010; Narayan and Smyth, 2005; Shahbaz et al. 2011; Shahbaz and Lean, 2012b; Shahbaz and Feridun, 2012). Further, few studies have considered electricity consumption and economic growth relationship in selected African economies (see Jumbe, 2004; Wolde-Rufael, 2006; Akinlo, 2009; Squalli, 2007; Odhiambo, 2009a, 2009b, 2010; Solarin, 2011and, Solarin and Bello, 2011). However, we are not aware of any study that has investigated causal relationship between electricity consumption and economic growth in the case of Angola.

In the present study, we investigate the direction of causality between economic growth and electricity consumption by incorporating urbanisation as a potential determinant of both electricity consumption and economic growth in the case of Angola. It is vital to explore the nexus between these variables in case of Angola because being one of the fastest growing economies in the world; it is faced with electricity challenges to fulfil its growing energy needs. For instance, the country was among the 3 fastest-growing economies in the World, upon attaining 17% economic growth rate between 2003 and 2008 (AFDB, 2011), whereas Angola's power sector is among the least efficient in the World and even in Africa (Pushak and Foster, 2011) as the access rate to electricity was around 26.2% in the year 2009 (World Bank, 2011). In order to avoid omitted variable bias associated with bivariate models

(Lutkepohl, 1982), urbanisation rate is included to transform the study into a trivariate investigation. In practice, urbanisation and electricity consumption may individually have direct influence on economic growth. They may also serve as intermediate variables to each other, when impacting the economy. Economic growth may in turn also affect either electricity consumption or urbanisation (see Abdel-Rahman et al. 2006; Davis and Henderson, 2003; Liu, 2009; Shahbaz and Lean, 2012a). In the Angola case, inclusion of urbanisation as a control variable is plausible as there are territorial dimensions to distribution of electricity in the country, with the effect of booming economic activities are concentrated in the urban centres, which are responsible for most of the electricity consumed in the country.

The present study augments the ARDL bounds test with Gregory-Hansen structural break cointegration, when testing for long run relationship in the series. Further, we compute the long run coefficients with the application of the ARDL, which is complemented with fully modified ordinary least squares (FMOLS) procedures of Philips and Hansen (1990) and dynamic ordinary least squares (DOLS) by Stock and Watson (1993), due to endogeniety concerns. The current paper provides for two-structural breaks with the procedures of Lee and Strazicich (2003) an exercise that is reasonable, considering the fact that the beginning and the end of the civil war in Angola falls within the scope of analysis.

The remainder of the paper is patterned as follows. Section-II deals with literature review related to electricity consumption and economic growth Section-III provides a summary of electric power in Angola and Section-IV illustrates the methodology employed in this study. Section-V provides empirical results and the last section completes the paper.

II. Literature Review

Theoretical and empirical studies on electricity consumption and economic growth linkage are widespread partly due to the significant role of energy in sustainable economic development. However, researchers are unable to arrive at a consensus on the flow of causality between energy consumption and economic growth. Conflicting results are present in papers on developed countries and adopt energy as proxy for energy usage (see Stern, 2000; Fatai et al. 2002; Glasure, 2002; Hondroyiannis et al. 2002; Ghali and El-Sakka, 2004; Oh and Lee, 2004; Ho and Siu, 2007 and Payne, 2009).

Similarly, papers with emphasis on developing countries that employ electricity use as proxy for energy consumption do produce different findings, thereby justifying differing hypotheses. For example, Aqeel and Butt, (2001) revealed one-way causation actually flows from electricity utilization to Pakistan's economy. Shahbaz and Lean, (2012b) probed the relationship between electricity consumption and economic growth in the case of Pakistan by incorporating capital and labour in production function over the period 1972-2009. They reported that electricity consumption adds in economic growth and bidirectional causality exists between both the series. On contrary, Jamil and Ahmad, (2010) also did same exercise and suggested that electricity conservation policies would be appropriate. A similar inference is drawn by Shahbaz and Feridun, (2012) on relationship between electricity consumption and economic growth using bivariate system[2].

Ghosh, (2002) applied Granger causality to examine causal relationship between electricity consumption and economic growth and reported the presence of expansion hypothesis in the case of India. However, the findings of Ghosh, (2009) support conservation policies in the case of India. Shiu and Lam, (2004) used data of electricity consumption and economic growth to test the direction of causality for Chinese economy. Their results indicated unidirectional causal relation running from electricity consumption to economic growth and same inference is drawn by Yuan et al. (2008). Moreover, Yang (2000) applied both Granger causality and Hsiao Granger causality tests and detected bidirectional causality in the case of Taiwan. On the other hand, Hu and Lin (2008) reported unidirectional causality flowing from economic growth to electricity consumption for Taiwan.

For Turkish economy, Altinay and Karagol (2005) investigated the relationship between electricity consumption and economic growth. They concluded that electricity consumption Granger causes economic growth. On contrary, Halicioglu (2007) also did same exercise to assess the relationship between electricity consumption and Turkish economy. His empirical evidence indicated unidirectional causality running from economic growth to electricity consumption. Although, Aktas and Yilmaz (2008) found that bidirectional causality between electricity consumption and economic growth exists. Latter on, Balat, (2009) also indicated that rising per capita income has significant impact on electricity demand. Acaravci and Qzturk, (2012) re-examined the electricity-growth nexus by incorporating employment as control variable in the case of Turkey. They reported unidirectional causality running from electricity consumption to economic growth.

In the case of Malaysia, Tang (2008) investigated the relationship between electricity consumption and economic growth using monthly frequency data over the period of 1972:1 to 2003:4. The results reported no cointegration between the series and feedback hypothesis was found using MWALD Granger causality test. Tang, (2009) reinvestigated the relationship between electricity consumption and economic growth by incorporating foreign direct investment and population in electricity demand function. He found that economic growth, foreign direct investment and population have positive impact on electricity consumption. Furthermore, electricity consumption, economic growth and foreign direct investment have bidirectional causality relationship. Chandran et al. (2010) probed the nexus between electricity consumption and economic growth by incorporating electricity prices. Their results reported that variables are cointegrated for long run relationship and electricity consumption Granger causes economic growth. On contrary, Lean and Smyth (2010) reported that unidirectional causality is running from economic growth to electricity consumption supporting the electricity conservation and management policies. Tang and Tan, (2013) reinvestigated the relationship between electricity consumption and economic growth by incorporating technological innovations in electricity demand model. They reported the existence of cointegration among the variables. Their results reported that income is positively linked with electricity consumption while electricity prices and technological innovations decline electricity consumption. The causality between electricity consumption and economic growth is running from both sides. Lorde et al. (2010) investigated the cointegration and causality between electricity consumption and economic growth in the case of Barbados. Their empirical evidence revealed cointegration and feedback hypothesis between electricity consumption and economic growth. Sami, (2011) applied trivariate model to investigate the causality among electricity consumption, exports and economic growth using data of Japan. He noted that exports and economic growth leads electricity consumption in long run but in short run, feedback effect exists between electricity consumption and economic growth and same is true for economic growth and exports. Electricity consumption Granger causes exports in short run. Shahbaz et al. (2012) applied trivariate model to explore the relationship between electricity consumption, capital use and economic growth in Romania. They found that electricity consumption and economic growth are having bidirectional causality relationship and electricity consumption is Granger cause of capital use. In Poland, Gurgul and Lach (2012) applied trivariate model to examine causality between electricity consumption, employment and economic growth. Their results indicated that economic growth Granger causes employment but neutral effect exists between electricity consumption and economic growth.

Country-specific studies in the case of Africa also exist including Odhiambo, (2009a) who investigated causality between the both variables in the case of South Africa and findings reported feedback hypothesis between electricity consumption and economic growth. Similarly, Jumbe (2004), Ouédraogo (2010) and KouaKou (2011) detected bidirectional relationship between electricity consumption and growth in Malawi, Burkina Faso and Cote D'Ivoire, respectively. However, Odhiambo (2010) examined causality between electricity consumption and economic growth with labour participation as an intermediate variable and concluded that economic growth is Granger caused by electricity consumption for Kenya. Same conclusion is reached by Odhiambo, (2009b) on relationship between electricity consumption and economic growth using bivariate system for Tanzania.

In the case of Ghana, Adom (2011) examined the causal relationship between electricity consumption and economic growth and reported that electricity consumption is Granger cause of economic growth implying growth led-energy hypothesis. Kwakwa, (2012) probed the relationship between electricity consumption and economic growth by adding fossil consumption. The empirical evidence revealed that electricity consumption and fossil consumption are Granger cause of economic growth. Adom et al. (2012) used electricity demand function by applying the ARDL bounds testing to examine the relationship between electricity consumption and economic growth. Their results indicated that income, industrial growth and urbanization are contributing factors to electricity consumption in Ghana.

Recently, Solarin and Bello (2011) probed the electricity-growth nexus for Nigerian economy by incorporating capital and labour in production function. They validated the presence of growth hypothesis which suggest the exploration of new sources of energy to sustain economic growth. Bélaïd and Abderrahmani, (2013) investigated the causality between electricity consumption, petroleum prices and economic growth using data of Algerian economy. Their findings show feedback effect between electricity consumption and economic growth and neutral hypothesis is validated for electricity consumption and petroleum prices.

Existing energy literature shows no studies examined the relationship between electricity consumption and economic growth in Angola. The direction of causality between both variables is very important and helpful for policy makers in articulating a comprehensive energy policy to stimulate economic growth in long span of time. This study is a pioneering effort to fill this gap in energy literature regarding Angolan economy.

III. Angolan economy

Angola is a Southern African country bordering the South Atlantic Ocean, Zambia to the East, Namibia to the South, and Democratic Republic of the Congo, to the North. With a landmass of 1,246,700 sq km and no inland water, the economy is endowed with numerous natural resources such as gold, diamonds, petroleum, which coincidentally constitute one of the major sources of electricity in the country (CIA, 2012). Upon gaining independence from Portugal on November 11 1975, the country immediately plunged into civil war that continued for 27 years. During the civil year (of which almost 1.5 million died and 4 million people were displaced), existing infrastructural facilities including infrastructure in the electricity sector were damaged or did not receive routine maintenance (CIA, 2012: IEA, 2006). Furthermore, rural population was particularly hard hit by the civil war, resulting in a huge influx of people into urban areas. Luanda (the capital of Angola), a city designed for a population of half a million, grew from 1.6 million in 1990 to about 3.6 million in 2002. Together with the other 17 provincial capitals and smaller urban centres, the urban population is estimated to be 7.4 million, which is 57% of 13 million in the year 2002 (World Bank, 2005).

The economy as a whole also suffered. During the first post-Independence decade (1975-85), average real growth probably did not exceed 1% per year (World Bank, 1991). Specifically, the level of output declined sharply in 1975 and 1976, while there was some recovery in the period 1977-81, and thereafter the GDP is estimated to have practically stagnated in subsequent years until 1986 when aggregate output again fell significantly. During the war era (1986-2002), the GDP per capita practically declined. For example, GDP per capita was USD 837.319 in 1987 but declined to USD 654.424 in 2001 (World Bank, 2011).

Buoyed by relative peace and increasing oil revenues, Angola has emerged from being far among African top ten economies in 2002 to become sixth largest economy in the continent[3]. GDP per capita grew from USD 722.252 in 2003 to USD 1370.737 in 2008. Due to global financial crises of 2008, the country suffered a setback with its GDP per capita declining to USD 1341.737, the economy however regain momentum as GDP per capita increased to USD 1381.004 in 2010 (World Bank, 2011). Angola’s growth rates from 2003 to 2008 averaged nearly 17%, placing it repeatedly among the 3 fastest-growing economies in the World (AFDB, 2011).

Electricity access is vital and constitutes a drive for sustainable economic growth. Electricity services are critical to Angola's economic and human development (IEA, 2006). The government has undertaken several measures to boost electricity supply over the years, especially after the civil war. Angola has been making substantial investments in the power sector since 2002 to restore and reconstruct the infrastructure that was destroyed during the civil war. This is evident in the low prices of electricity in the country as the government heavily subsidise the two power utilities companies-National Electricity Company (or ENE, created in 1980 and produces power and distributes around 30% of it in the south and central region) and Electricity Distribution Company of Luanda (or EDEL that buys power from ENE and distributes the remaining 70% in the north of the country)[4]. Moreover, there has been improvement in the electricity production in the country. From Fig. 1, it is shown that electricity production increased from 118.532 KWh per capita in 2002 to 168.960 KWh per capita in 2005 and further to 224.843 KWh per capita in 2009. Table 1 reveals that most of electricity in the country is sourced from hydropower in Angola (World Bank, 2011).

Relating the figures of electricity production and electricity consumption may tend to obscure the electricity problems faced in Angola, as Fig. 1 reveals constant electricity surplus over the years with surplus of 23.062 KWh per capita and 22.689 KWh per capita in 2008 and 2009, respectively. Despite the expansion of power-generation capacity, deficient transmission and distribution infrastructure prevents electricity from flowing to customers, and reliability of supply remains very poor with access to electricity was around 30% and 26.2% in 2008 and 2009. These figures are low in comparison with 46% average for the nation's resource-rich African peers in 2008 or 67.3% of lower and middle countries and 62.2% of South Asian countries in 2009 (World Bank, 2011; Pushak and Foster, 2011).

However, there are territorial dimensions to the distribution of electricity in the country, with urban areas tend to consume most electricity available in the country. For example, Luanda absorbs around two-thirds of the nation's electricity, suggesting relatively high access in the urban and peri-urban areas of the capital (Pushak and Foster, 2011). About 85% of Luanda's municipalities indicate that they use electricity for lighting, corroborating the fact that electricity and urbanisation seems to be related (World Bank, 2005).

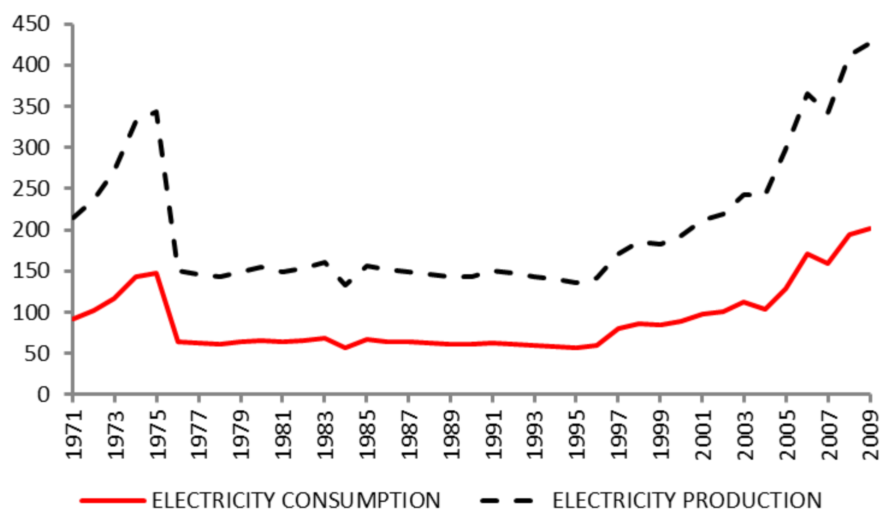

Fig. 1 Trend of electricity consumption and electricity production in Angola, 1971-2009

Table 1: Angola electricity Sources

Year	1971	1981	1991	2001	2005	2006	2007	2008	2009
Hydro	81.54	88.15	82.66	62.09	79.65	80.61	77.62	79.75	76.05
Oil	18.46	11.85	17.34	37.91	20.35	19.39	22.38	20.25	23.95

Source: World Development Indicators (World Bank, 2011). Figures are in percentages.

IV. Methodological Framework

Existing studies have demonstrated that the flow of causality in electricity consumption, urbanisation and economic growth may vary (Abdel-Rahman et al. 2006; Shahbaz and Lean, 2012a). Estimation in which any of the series is *a prior* assumed as dependent with others as independent may therefore be questionable. In this paper, we specified a model in which exogeneity of each series is not determined *a prior*. Our models appear in a double-log functional specification, which yields better result relative to linear functional form because of the logarithmic transformation:

$$Y_t = f(EC_t, URB_t) \tag{1}$$

Y_t is the real GDP per capita, EC_t is electricity consumption per capita, and URB_t is urbanisation, defined as population in urban centres divided by total population. The estimates yield elasticities of independent variables with respect to dependent variable, because the series are in logarithmic form. This model is not in isolation as previous studies such as Liu (2009) and Shahbaz and Lean (2012a) included urbanisation as one of the potential variables in the regression(s) involving energy consumption and economic growth. In theory, urbanization involves structural changes throughout an economy and has important implication to energy consumption. It is both driven by and intensely determines the processes and context of economic development (Alam et al., 2007). Urbanization leads to substantial concentration of population generating economic activities; and thus increases the demand for energy. Mishra et al. (2009) showed that energy consumption is caused by urbanization in short run for the Pacific Island nations. In long run, energy consumption and urbanization Granger cause GDP (Shahbaz and Lean, 2012a). The study employs annual data over the period of 1971-2009 in case of Angola. Data on real GDP per capita, electricity consumption per capita and urbanisation have been sourced from *World Development Indicators* (World Bank, 2011) and Angus Maddison's homepage (at http://www.ggdc.net/maddison/Maddison)[5].

Various unit root tests have been applied to test the order of integration of the variables, inclusive of Augmented Dickey Fuller (ADF) test by Dickey and Fuller, (1979) and PP test by Phillip and Perron, (1988) that turn out to be less dependable upon the occurrence of structural break(s). They are bias against rejecting the null of a unit root when the time series under investigation is stationary around a structural break (Perron, 1989). So, unit root tests such as Perron, (1989); Zivot and Andrews, (1992) and Lumsdaine and Papell, (1997) provide unit root analysis in the presence of structural breaks stemming in the series. Perron, (1989) method of exogenous determination of structural break has been challenged on the premise of introducing a subjective method of selecting structural break point. Zivot and Andrews, (1992) correct the problem of subjective selection of break by proposing a unit root method, which endogenously determines one structural break in the series. Due to the possibility of more than single break, Lumsdaine and Papell (1997) extend the Zivot and Andrews, (1992) unit root test to include two unknown structural breaks. These endogenous tests assume no break(s) under the null of unit root and derive their critical values, accordingly. This causes size distortion in such a way that the null hypothesis of unit root is often rejected than necessary. Further, Lee and Strazicich (2001) observed that Lumsdaine and Papell, (1997) calculate the break incorrectly at one period behind the true break which increases the size of break point. Lee and Strazicich, (2003, 2004) resolved this problem by proposing a different method of testing for unit root with an endogenous structural break that is not impaired by breaks under the null.

We apply the ARDL bounds testing approach to cointegration developed by Pesaran et al. (2001) to examine the existence of long run relationship between the variables. Various cointegration approaches are available in empirical economics literature, for example, Engle and Granger (1987), Johansen (1988) and, Johansen and Juselius (1990) etc. The ARDL bounds testing uses single reduced form equation, while Engle and Granger, (1987) requires two-stage regression, such that the error generated in the first stage is transmitted to the next stage. Bound testing is relevant irrespective of the series being purely I(0), I(1) or mutually cointegrated. Different from Johansen cointegration approach which require large data sample, bound testing is more suitable for small sample size data. Further, critical values often quoted for Johansen cointegration test are inappropriate (Turner, 2009), whereas the ARDL approach operates on standard(s) critical values. The approach of bound testing entails ordinary test squares (OLS) technique on unrestricted error correction model:

$$\begin{aligned}\Delta Y_t = \xi_{10} + \xi_{11} T + \sum_{i=1}^{p} \xi_{12} \Delta Y_{t-i} + \sum_{i=0}^{q} \xi_{13} \Delta EC_{t-i} + \sum_{i=0}^{r} \xi_{14} \Delta URB_{t-i} \\ + \lambda_1 Y_{t-1} + \lambda_2 EC_{t-1} + \lambda_3 URB_{t-1} + \mu_{1i}\end{aligned} \quad (2)$$

$$\begin{aligned}\Delta EC_t = \xi_{20} + \xi_{21} T + \sum_{i=1}^{p} \xi_{22} \Delta EC_{t-i} + \sum_{i=0}^{q} \xi_{23} \Delta Y_{t-i} + \sum_{i=0}^{r} \xi_{24} \Delta URB_{t-i} \\ + \lambda_1 Y_{t-1} + \lambda_2 EC_{t-1} + \lambda_3 URB_{t-1} + \mu_{2i}\end{aligned} \quad (3)$$

$$\begin{aligned}\Delta URB_t = \xi_{30} + \xi_{31} T + \sum_{i=1}^{p} \xi_{32} \Delta URB_{t-i} + \sum_{i=0}^{q} \xi_{33} \Delta Y_{t-i} + \sum_{i=0}^{r} \xi_{34} \Delta EC_{t-i} \\ + \lambda_1 Y_{t-1} + \lambda_2 EC_{t-1} + \lambda_3 URB_{t-1} + \mu_{3i}\end{aligned} \quad (4)$$

Here Δ is the first difference operator and all the variables are in logarithmic form. The residuals μ_t are assumed to satisfy classical properties assumption. In order to verify the presence of the long run relationship, Pesaran et al. (2001) suggest the use of *F-test* on lagged terms in equations (2) to (4). The null hypothesis of no cointegration is $(H_0 : \lambda_1 = \lambda_2 = \lambda_3 = 0)$ while alternate hypothesis of cointegration is $H_a : \lambda_1 \neq \lambda_2 \neq \lambda_3 \neq 0$. Besides, Pesaran et al. (2001) constructed two sets of asymptotic critical values for bounds testing -which are called lower critical bounds (LCB) and upper critical bounds (UCB). Nevertheless, critical values proposed in Pesaran et al. (2001) are not suitable for finite sample size (as they were estimated for sample sizes of 500 and 1000 observations. Narayan, (2005) produced new sets of critical values, which better suit small sample data. This paper implements critical values of Narayan, (2005). According to the bound testing procedure, iif the computed F-statistic is less than the lower bound critical value, then null hypothesis is accepted, signifying non-existence of cointegration. If the computed F-statistic is more than the upper bound critical value, the null hypothesis is rejected, demonstrating cointegration. The result becomes inconclusive, if the computed F-statistic falls within the critical bounds.

This paper assesses possible direction of causation(s) within the series with Granger causality test, after establishing long run relationship. Contingent on the occurrence of cointegration, Granger causality is conducted within the framework of a VECM as follows:

$$(1-L)\begin{bmatrix} \ln Y_t \\ \ln EC_t \\ \ln URB_t \end{bmatrix} = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} B_{11i} B_{12i} B_{13i} B_{14i} B_{15i} \\ B_{21i} B_{22i} B_{23i} B_{24i} B_{25i} \\ B_{31i} B_{32i} B_{33i} B_{34i} B_{35i} \end{bmatrix} \times \begin{bmatrix} \ln Y_{t-1} \\ \ln EC_{t-1} \\ \ln URB_{t-1} \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \end{bmatrix} \quad (5)$$

Where $(1 - L)$ is the difference operator, ECT_{t-1} is the lagged error correction term. ε_{it} are premised on the assumption of constant variance, zero mean and normal distribution. The significance of t-statistic of the ECT_{t-1} indicates the presence of long run causal relationship between the variables. Short run causality is suggested by the significance of F-statistic of the lagged variables. For example, electricity consumption leads economic growth if, $B_{12,i} \neq 0 \forall_i$ while $B_{21,i} \neq 0 \forall_i$ suggests that economic growth Granger causes electricity consumption.

Table-2: Unit root test

Variable	Panel-A: ADF, PP and Lee and Strazicich (2004)									
	ADF		PP		Lee and Strazicich (2004)					
	Level	1st Diff.	Level	1st Diff.	Level			1st Diff.		
	T-stat	T-stat	T-stat	T-stat	T-stat	TB	λ	T-stat	TB	λ
$\ln Y_t$	-0.575[5]	-3.313*[5]	-1.757[5]	-3.861**[5]	-3.527[1]	1997	(0.6)	-4.899**[4]	1992	(0.6)
$\ln EC_t$	-1.064[0]	-3.673**[5]	-2.852[0]	-8.538***[5]	-3.392[1]	1992	(0.6)	-6.996***[1]	1976	(0.2)
$\ln URB_t$	-1.814[5]	-3.154*[3]	2.480[5]	-7.788***[3]	-3.181[2]	1977	(0.2)	-4.402*[5]	1995	(0.6)

	Panel-B: Lee and Strazicich (2003)							
	Level				1st Diff.			
	T-stat	TB (1)	TB (2)	λ_1 λ_2	T-stat	TB (1)	TB (2)	λ_1 λ_2
$\ln Y_t$	-4.757[1]	1975	1993	(0.2, 0.6)	-6.839***[3]	1985	1992	(0.4, 0.6)
$\ln EC_t$	-5.240[3]	1978	1992	(0.2, 0.6)	-6.419***[2]	1979	2003	(0.2, 0.8)

$\ln URB_t$	-3.718[1]	1986	1998	(0.4, 0.6)	-5.815** [5]	1994	2002	(0.6, 0.8)	
Lee and Strazicich (2003) Critical Values									
	0.4			0.6			0.8		
	10%	5%	1%	10%	5%	1%	10%	5%	1%
0.2	-5.27	-5.59	-6.16	-5.32	-5.74	-6.41	-5.33	-5.71	-6.33
0.4	-	-	-	-5.31	-5.67	-6.45	-5.32	-5.65	-6.42
0.6	-	-	-	-	-	-	-5.32	-5.73	-6.32

Note: *, ** and *** denote significance at 10%, 5% and 1% levels, respectively. Optimal lag order for ADF test is determined by Akaike Information Criterion, while the spectral estimation of PP is based AR spectral Information Criterion, while the spectral estimation of PP is based AR spectral OLS, with Akaike Information Criterion as basis for optimal lag length. Critical values are for ADF and PP are from MacKinnon (1996), while critical values for Lee and Strazicich one break tests obtained from Lee and Strazicich (2004) are (-4.17 to -4.21), (-4.45 to -4.51) and (-5.05 to -5.15) for 10%, 5% and 1% levels, respectively [] is optimal lag. TB is the structural break date(s)

Existing empirical literature indicates that the ARDL bounds testing for cointegration does not depend on knowledge whether variables are integrated at I(0) or I(1) or variables have mixed order of integration. However, the ARDL becomes inappropriate if any series achieves stationarity at a point beyond first difference or I(2). As a result, we have applied the ADF, PP and Lee and Strazicich, (2004) unit root tests. The findings of stationarity tests are presented in Table-2. The ADF, PP and Lee and Strazicich, (2004) one structural break results are reported in Panel-A of Table-2. Beginning with ADF test, we observe null hypothesis of unit root cannot be rejected for the series at level with intercept and trend but the hypothesis of unit root is rejected for all the variables at first difference. The PP unit root tests illustrate same results and indicate that the series are integrated at I(1). However, the powers of ADF and PP unit root tests are weakened, when structural break exists; hence the tests must be supported with additional tests such as Lee and Starzicich, (2003, 2004) structural break unit root tests.

Using Lee and Starzicich (2004), we note that null hypothesis of unit root cannot be rejected for any of the series at level. The null of non-stationarity is rejected for all the variables once variables are 1^{st} differenced, validating that findings of the ADF and PP unit root tests are reliable and robust. In reality, the strength of Lee and Strazicich, (2004) with one structural break becomes weakened in the presence of more than one structural breaks stemming in the series. So, we reported the results of Lee and Strazicich, (2003) unit root test in Panel-B of Table-2. The results indicate that none of any variables is found stationary at level. This concludes that all the series are found to be stationary at 1^{st} difference. Coefficients of the structural breaks (which are available upon request) are noted to be significant. Roughly 30% of the structural breaks correspond to the start and end of the civil war in Angola.

Table-3: ARDL cointegration test

Bounds testing to cointegration			Diagnostic tests		
Dependent Variable	Optimal lag	F-Statistics	χ^2_{SERIAL}	χ^2_{ARCH}	χ^2_{NORMAL}
$\ln Y_t$	(3,3,3)	5.724**	0.680[1]	0.306[1]	0.179[1]
$\ln EC_t$	(3,3,2)	8.736***	0.142[1]	0.750[1]	0.507[2]
$\ln URB_t$	(2,4,3)	5.495*	0.257[1]	0.153[1]	0.166[2]

Critical Values	10%I(0)	10%I(1)	5%I(0)	5%I(1)	1%I(0)	1%I(1)
Narayan (2005)	3.760	4.795	4.510	5.643	6.238	7.740

Note: ***, ** and * denote significance at 1%5% and 10% levels, respectively. Critical values are for model with restricted intercept and no trend. The null is no cointegration. Optimal lag length is determined by Akaike Information Criterion. Probability values are reported for diagnostics tests, with [ ] as the order of diagnostic tests.

The unique stationarity properties of the variables lead us to apply the ARDL bounds testing approach to examine cointegration between the variables for long run relationship. The findings of the bounds test are reported in Table-3. Our empirical exercise illustrates the presence of cointegration once economic growth, electricity consumption and urbanisation are assigned as dependent variables. Our computed F-statistics are 5.724, 8.736 and 5.495 are greater than upper critical bound at 5%, 1% and 10% levels respectively. This implies that there are cointegration vectors in economic growth, electricity consumption and urbanization equations. We may conclude that cointegration is found between the series for long run relationship over the study period in case of Angola. The reliability of the ARDL bounds testing becomes unreliable once structural break stems in the series. To overcome this issue, we have implemented Gregory-Hansen structural break cointegration approach which informs about one structural beak. The results as detailed in Table-4 indicate the null of no long run relationship cannot be rejected when economic growth, electricity consumption and urbanisation are entered as dependent variables. The empirical exercise further reveals that the structural breaks are concentrated in the neighbourhood of the year 1975, which ushered in the civil war. In sum, these suggest the existence of cointegration and breaks; corroborating the earlier findings.

Table-4: Gregory-Hansen Structural Break Cointegration Test

Dependent Variable	$\ln Y_t$	$\ln EC_t$	$\ln URB_t$
ADF-Test	-5.508***[0]	-7.104***[0]	-6.850***[2]
TB	1977	1978	1977

Note: ** shows significance at the 5% level. The ADF statistics show the Gregory-Hansen tests of cointegration with an endogenous break in the intercept. Critical values for the ADF test (for two regressors) at 1%, 5% and 10% are -5.44, -4.92 and -4.69 respectively. The t-test is used to determine the optimal lag length (out of a maximum 4), while the trimming region is set at 0.10. TB is the structural break date

Table-5: The VECM Granger Causality Analysis

Dependent Variable	Direction of Causality			
	Short Run			Long Run
	$\Delta\ln Y_{t-i}$	$\Delta\ln EC_{t-i}$	$\Delta\ln URB_{t-i}$	ECT_{t-1}

$\Delta \ln Y_t$	....	2.853*** [0.073]	0.816 [0.452]	-0.452** [-2.089]
$\Delta \ln EC_t$	1.122** [0.339]	....	3.245*** [0.052]	-0.3901** [-2.426]
$\Delta \ln URB_t$	0.570 [0.572]	3.1722*** [0.056]	....	-0.197*** [-1.731]
Note: *, ** and *** show significance at 10, 5 and 1 per cent levels respectively.				

Table-5 presents the results of the VECM Granger causality, which are very pertinent to players in the realm of energy, environment, and economic policy making. Since the series exhibit cointegration link, flows of causality are divided into short-and-long runs. In long run, results indicate the bidirectional causality exists between electricity consumption and economic growth, feedback hypothesis is found between urbanisation and electricity consumption, and economic growth and urbanisation Granger cause each other. Our results are lined with the findings of Odhiambo (2009a) for South Africa, Jumbe (2004) for Malawi Ouédraogo (2010) for Burkina Faso and KouaKou (2011) for Cote D'Ivoire, which are fellow African Countries. For short run, bidirectional causality exists between electricity consumption and economic growth and same inference is noted for urbanisation and electricity consumption. The neutral hypothesis is found between urbanisation and economic growth. In summary, bidirectional causal relationship is present among the series; however, these interpretations ignore the direction in which explanatory variables affect the dependent variables. Positive and significant signs of electricity consumption in a growth equation support energy expansionist proposition. In the next section, the study proceeds with the estimation of long and short run elasticities. Due to robustness concerns, the ARDL long run outputs are augmented with the estimates of the FMOLS and the DOLS following Narayan, (2005)[6]. This is necessary in order to determine the pattern in which electricity and urbanization actually affect economic growth especially in long run.

Table-6: Long-run and short-run elasticities

Panel A: Long run elasticities						
Dependent Variable	$\ln Y_t$					
	ARDL		FMOLS		DOLS	
Period	$\ln EC_t$	$\ln URB_t$	$\ln EC_t$	$\ln URB_t$	$\ln EC_t$	$\ln URB_t$
1971-2009	0.759***	0.200	0.722***	-0.431***	0.948***	0.060
1975-2002	0.372***	-0.363***	0.296**	-0.376***	0.581	-0.263

Panel B: Short run elasticities					
Dependent Variable	$\Delta \ln Y_t$				
Period	$\Delta \ln EC_t$			$\Delta \ln URB_t$	
1971-2009	0.120			13.470*	
1975-2002	-0.142			-0.414**	

Note: ***, ** and * denote significance at the 1%, 5% and 10% levels, respectively. Optimal lag for ARDL is based on Akaike Information Criterion, while optimal lag for FMOLS is based on Bartlett weights. As required, we apply Newey-West on the estimates of DOLS.

In Table-6, we report the long run and short run elasticities, with economic growth entering as dependent variable. In Panel-A of Table-6, the ARDL long run elasticities are presented along with outputs of the FMOLS and the DOLS for the entire period of the sample size. Overwhelmingly, electricity consumption turns out with positive impact on economic growth corroborating the idea of energy expansionist. These results are akin to the findings of Quédraogo (2010) and Solarin and Bello (2011) for Burkina Faso and Nigeria, respectively. Considering the period of civil war in Angola (1975-2002), we detect long run positive influence of electricity consumption on growth, but with weakened coefficient in comparison with the period of full-sample. The coefficient of urbanisation suggests that urbanisation is negatively impacted on economic growth during the civil war and it is insignificant for the entire sample period. Urbanisation involves structural changes throughout an economy and has important implication to energy consumption in Angola, where electricity distribution is associated with the recent booming economic activities in the urban centres. Based on the notion, the coefficient of urbanisation should yield significant positive impact on economic growth. However, the Angolan civil war (which accounts for a large percentage of our sample period) was an overridden factor in the movement of people (similar to few other African countries) as hundreds of thousands of people displaced by wars sought refuge in capital cities (Sommers, 2003). During this period, there was the destruction of several production forms in rural areas, due to the civil war. The negative coefficient of the urbanisation seems to be capturing this phenomenon in the country[7]. The short run coefficients, presented in Panel-B of Table-6, reveal that electricity consumption does not have significant impact on economic growth. With these findings; policies aimed at improving energy (and electricity) facilities will improve the economy, especially in the long run. In other words, energy conservation policies could hinder economic growth in long run.

V. Conclusion

This study investigates causality between economic growth and electricity consumption in Angola over the period of 1971-2009. The model is augmented with urbanisation as a control variable. We applied the ARDL bounds testing approach to examine cointegration and the VECM Granger causality approach to detect direction of causal relationship between the variables. Three cointegrating vectors were established, suggesting the existence of long run relationship between the variables. Results illustrate bidirectional causality between electricity consumption and economic growth in line with the findings of Odhiambo, (2009a) for South Africa, a fellow African country. Feedback hypothesis is observed between urbanisation and economic growth, and between electricity consumption and urbanisation. Besides, long run coefficients of three estimators (the ARDL, the FMOLS and the DOLS) generally indicate Angola's electricity consumption positively contribute to economic growth. The coefficients were weakened, with less positive impact of electricity consumption on economic growth during the civil war.

These foregoing results support the energy expansionist view. As a result, authorities in Angola must not only continue to invest in the area of electricity generation, but also explore other sources of electricity in the country. Being oil abundant country, natural gas as a source of electricity should be stimulated, which will not only lessen electricity' cost but also reduce health hazard triggered by gas flaring in the country.

In the area of transmission and distribution of electricity, promotion of private participation to complement the (inadequate) distribution capacity of NEC (National Electricity Company) and EDEL (Electricity Distribution Company of Luanda) is necessary to further liberalised the sector. Local initiative and contribution should be encouraged in combination with foreign involvement. Similarly, fair competition among potential private distributors may turn out as catalyst for growth of energy in the country. Outside the period of civil war, rapid urbanisation is attributable to developing countries that can either positively influence an economy through technological creativity and economic progress or negatively impact the economy via its effect on straining infrastructures (Alam et al. 2007). It is left for policy-makers and planners to shape urbanization policies in such a way as to make it a positive force for economic development, especially when pursuing energy expansionist programmes. Relevant policies to encourage the contribution of urbanisation involve infrastructure investments, trade protection policies and price controls (Henderson, 2003). Above all, effective regulation of the electricity market is needed in securing quality of service, adequacy of technical, commercial and managerial know-how of staff, fair tariffs to electricity users, reasonable remuneration for potential investor and creation of accommodating atmosphere. The authorities should borrow a leaf from modern national standards and international best practice in setting the blue print for the electricity sector.

For future research, present study may reinvestigated by incorporating capital and labour as potential determinants of economic growth using Cobb-Doulas production following Shahbaz and Lean, (2012a). The study has potential to incorporate trade openness (Sadorsky, 2010, 2011) and financial development (Shahbaz and Lean, 2012a). Financial development can affect electricity consumption by offering cheaper loans to consumer and producer. Trade openness may also influence electricity consumption through exports-enhancement effect and importing energy efficient technology to be used in production to increase domestic output. An investigation of sectoral electricity-growth nexus not only provide rigor empirical analysis but also helps policy makers in articulating a comprehensive energy policy to sustain economic growth for long run.

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Endnotes

[1]Although this analogy is commonplace in existing energy literature, the signs of the long run coefficients are actually required to ascertain if electricity consumption and economic growth are positively related or otherwise.

[2]Findings by Shahbaz and Feridun (2012) may be biased due to avoiding the role of capital and labor in production function and their impact on electricity consumption. Furthermore, Nawaz et al. (2012) reported unidirectional causality running from economic growth to energy consumption.

[3] Angola has not only become the second largest producer of oil, but also second largest in terms of oil reserves in Africa, after Nigeria. In 2009, Angola briefly became the largest oil producer, because of incessant attacks on oil infrastructures in the Niger Delta of Nigeria. In 2007, Angola formally became a member of OPEC and in 2009, held the presidency of the Organization.

[4] In 2000, ENE received a direct subsidy of $150 million plus fuel subsidies that together covered 25 percent of its costs (Pushak and Foster, 2011)

[5] Data in Madison's homepage is based on 1990 International Geary-Khamis dollars, which adjusts for purchasing power parity in currencies and international average prices in commodities (Strazicich et al. 2004).

[6]One requirements for applying FMOLS is that the right-hand-side variables must not be collectively *I(0),* a condition fulfilled by the data. The test is available upon request. .

[7] We thank an anonymous referee's suggestion on the implication of urbanization in Angola.