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Revisiting the Electricity Consumption-Economic Growth Nexus in Angola: The Role of Exports, Imports and Urbanization

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ABSTRACT

The present study aims to reinvestigate the relationship between electricity consumption and economic growth in Angola by introducing exports, imports and urbanization in the production function. We utilize the combined cointegration method to test the long-run relationship for the period of 1971-2012. Whilst accommodating structural breaks, the autoregressive distributed lag bounds test approach is applied to examine the robustness of the long-run relationship in the variables. The results reveal that electricity consumption boosts economic growth but urbanization impairs it. The vector error correction method causality results unveil the feedback relationship of electricity consumption with economic growth, exports and imports. It is, therefore, suggested that the policy makers should formulate the policies to improve the electricity supply that in turn will enhance the economic growth.

Keywords: Electricity Consumption, Economic Growth, Combined Cointegration Test, Granger Causality Test
JEL Classifications: C32, O55, Q43

1. INTRODUCTION

Electricity is vital for human survival and development as its use is necessary for some indispensable household activities, namely lighting, cooking, cooling and the activation of domestic devices. In several economies, access to electricity is often used as benchmark for evaluating governments' performances, especially across the developing countries. An adequate electricity supply may boost output of firms by improving the labor and capital productivity (Kouakou, 2011). However, the distribution of electricity is not equal across the world as several developed countries have abundance of electric power, while many developing countries are known to suffer from chronic inadequate electricity supply (Iyke, 2015). More than a century after the light bulb was invented, electricity generation in Africa is acutely inadequate, unreliable and in some extreme cases, non-existent. Angola is one of the countries located in the continent and a typical example of the general problem of electricity shortage that the region is facing (Ministry of Planning and Territorial Development, 2012).

With a gross domestic product (GDP) of more than USD114 billion and GDP per capita of USD 5,482 Angola is one of the biggest economy in Africa (World Bank, 2014). Angola's economy is heavily reliant on its oil industry, which is responsible for around 80% of the government revenues and 40% of the GDP (Energy Information Agency, 2014). However, much of the wealth generated from oil in the country hardly finds its way to the general population, and a considerable part of the nation's infrastructure remains undeveloped or damaged from the 27-year-long civil war (1975-2012), which resulted in almost four million people displaced and two million deaths (KPMG, 2013). Due to the massive devastation to the network of electricity supply caused by the civil war, Angola experiences poor supply of electric power and regular power outages, thereby, forcing many residential buildings and nearly all firms located in the country to search for alternative sources of power (Ministry of Energy and Water, 2010). The rise in urbanisation rate and the prevalence of suburban areas nearby the major cities has led to a remarkable increase in the number of illegal connections to the national grid, adding to the problem of power shortages. The capital-Luanda consumes more than 70% of the nation's power output but only around 25% of the inhabitants of the city enjoy frequent electricity supply. Beyond the major cities, residents of the rural areas do not enjoy electricity, with the exceptions of the towns located near to Angola's hydroelectric dams (Ministry of Energy and Water, 2007; Energy Information Agency, 2014). Generally, less than one-fifth of the country's population enjoy electric power, while most households still depend on wood or charcoal. Candles, kerosene and paraffin are very popular among urban citizens as they are still the principal sources of lighting, given the inaccessibility of obtaining wood (KPMG, 2013).

After the civil war, the government-alongside the state-owned electricity provider Empresa Nacional de Electricidade or ENE, have undertaken a massive set of programmes aimed at enhancing the generation capacity, developing and refurbishing the power networks in the urban centres, establishing a comprehensive national grid, with the priority of bringing electricity supplies to rural areas, which include the revamping of the existing dams (Ministry of Planning and Territorial Development, 2012). Upon the conclusion of the civil war in 2002, the electricity generation capacity of the country's power sector was upgraded to 1,160 megawatts (mw) in 2007, of which 23% was from diesel and 77% was from hydroelectricity (KPMG, 2013). Angola has enormous hydroelectric resources, due to its large river system, but only a tiny amount is being utilized, with its potential being estimated at 18,000 mw. The recent refurbishment of some dams has raised the capability of the Cambambe, Capanda and Matala dams to 520 mw, 180 mw and 51 mw, respectively (KPMG, 2013). In spite of the latest upgrading of capacity, the country's national power grid is still feeble and insufficiently connected, with a considerable amount of electric power lost in transit. Power shortages are widespread, aggravated by ineptitude maintenance culture, recurrence of stolen cables and under-pricing of electricity bills (KPMG, 2013).

Given the challenges faced by the electricity sector of Angola, it is pertinent to reinvestigate the electricity policy suitable for the development of the country. Causal scrutiny of the relationship between electricity consumption and economic growth offers energy authorities a straight forward policy guide. Depending on the outcome, the pattern of causality between these variables may imply energy conservation blueprints; energy expansion programmes or instances where there is no need to engage in any active energy policy because any move will bear no consequence on the economy (Cui, 2016; Ozturk, 2010; Iyke, 2015; Sebri, 2015; Ozturk and Al-Mulali, 2015; Solarin and Ozturk, 2015; 2016). With the exception of Solarin and Shahbaz (2013), to the best of the authors' knowledge, we are not aware of any study that has undertaken similar exercise in the case of Angola. In this paper, we re-examine the causal relationship between electricity consumption and economic growth in the country, while adding urbanization rate, exports and imports to the model. In doing so, we contribute to the literature on the nexus in several ways. Contrary to the paper by Solarin and Shahbaz (2013), we introduce more than one control variable into the model. The inclusion of more variables, in addition to energy and urbanization rate, provides greater information that influences aggregate output more than in the trivariate case Therefore, research on the energy-growth nexus should incorporate other relevant variable(s) that influence economic growth and energy consumption (Tang and Tan, 2013). Secondly, the choice of our additional variables is also another contribution as this is the first African study to use exports and imports as control variables. Many multivariate studies in the continent have ignored these two important series. It is worth noting that many African countries are largely agrarian and known for their reliance on exports of agricultural products and other natural resources as their major source of foreign exchange and employment. Further, African countries import capital-intensive foods and heavy machineries, which are utilized in several industries across the continent in the course of production. Beyond the significance of exports and imports in the Africa, including these two series in an electricity-growth model effectively coincides the Granger causality literatures on the energy-GDP, exports-GDP and imports-GDP nexus. The addition of imports and exports in the econometric model not only improves the model specifications, it also provides the opportunity to evaluate the validity of the energy-led growth hypothesis, the exports-led growth hypothesis and the imports-led growth hypothesis. On the top of that, we use assortments of econometric procedures, including the Bayer and Hanck (2013) cointegration approach, which is a relatively recent time series methodology capable of unravelling relationships that might not be likely captured by traditional approaches.

The results reveal that electricity consumption boosts economic growth but urbanization impairs it. The vector error correction method (VECM) causality results unveil the feedback relationship of electricity consumption with economic growth exports and imports. Our results also have specific implications for the levels of imports and exports (especially non-oil exports) in the country. Since there is bidirectional causality between the variables, any initiative to improve electricity activities will influence imports and exports, and vice versa. The insufficiency in power supply is regarded as one of the major constraints to business as 68% of firms depend on personal diesel generators (African Economic Outlook, 2012). Improved electricity will increase business activities and domestic production levels, which may decrease reliance on imports and increase exports of goods and services. The African country is deeply dependent on food imports, which is the responsible for 90% of the total food consumed with the immediate negative impact felt in the country's current account (The Herald, 2014; World Bank, 2013). Imports are increasingly being funded by new credit lines from either Paris Club members that have signed bilateral debt renegotiation agreements or from non-OECD countries, such as Brazil, Israel, Russia and China (African Economic Outlook, 2007; 2012). Moreover, boosting electricity will enhance the level of exports, especially non-oil exports, which currently account for 4% of the total exports (World Bank, 2013). The changes in imports and exports will improve the economy of Angola. Improving exports and discouraging import will swell economic growth as the long-run regression has implied. Concerning urbanisation, the results show that it will lead to declines in economic growth. It is the responsibilities of the constituted authorities to roll out policies that will ensure that urbanisation contribute positively to economic development, especially when implementing energy expansionist blueprints (Solarin and Shahbaz, 2013).

However, for a fruitful success of these expansionary policies, the authorities must also ensure that the cost and procedures of accessing electricity in the country are streamlined. As it stands, the cost and procedures of obtaining electricity in Angola is not encouraging, even when using the situation in the African continent as a benchmark (World Bank, 2013). In terms of access to electricity, Angola has been ranked 170 out of 189 and the cost of obtaining electricity as a percentage of the economy's income per capita was 687% in the year 2013. In the same year, the number of days to obtain a permanent electricity connection in the country was 145 days, with the Sub-Saharan averaging 141 days (World Bank, 2013).

The remainder of the paper is organised as follows. Section II deals with the prior papers on electricity consumption and economic growth in Africa, while Section III illustrates the data and methodology adopted in this paper, Section IV provides the empirical findings, and finally, Section V presents the conclusions of the study as well as policy implications.

2. LITERATURE REVIEW

Given the pivotal role of electricity in the course of economic growth as well as the significant policy implications arising from examining the causal relationship between electricity consumption and economic growth, many economists have attempted to study the relationship between the two series. Started in the late 1970s, the initial focus of the literature was on the causal relationship in developed countries and was also within a bivariate framework. Concerned with the growing dilapidation of electricity facilities in developing countries, more recent papers are now considering the nexus in developing countries with the aim of prescribing policies that may be suitable for the electricity sector of such economies. With the introduction of more sophisticated econometrics techniques and coupled with the fear that bivariate studies are susceptible to omission of variable biasness; latter works are increasingly incorporating more series into the energy-GDP model. Generally, the literature on electricity and economic growth is widespread at the moment. Recently, both Ozturk (2010) and Payne (2010) have undertaken detailed literature surveys on the energy-growth nexus. Therefore, we restrict our literature survey to the studies that examine the causal relationship between electricity and economic growth in African countries.

We begin our survey with the studies that have adopted bivariate framework. One of the earliest works in the continent is that by Jumbe (2004) who conducts an empirical exercise on the link between, agricultural-GDP, non-agricultural GDP, overall GDP and electricity consumption in Malawi over the period, 1970-1999. Test statistics from the Engle and Granger (1987) cointegration test show the presence of a long-run link between electricity consumption and total GDP and also between electricity consumption and non-agricultural GDP. However, the study failed to find any long run link between electricity consumption and agricultural GDP. The Granger causality tests illustrate one-way long run causality running from total GDP and non-agricultural GDP to electricity consumption. Kouakou (2011) uses annual series from 1971 to 2008 to study the relationship between electricity consumption and economic growth as well as the link between electricity consumption and industry value added in the case of Cote d'Ivoire. Using the autoregressive distributed lag (ARDL) bounds testing approach, test statistics reveal the cointegration. The results provide evidence for long-run causality running from electricity consumption to both economic growth and industry value added. Odhiambo (2009a) employs the ARDL bounds testing methodology to determine the long-run relationship between electricity consumption and economic growth in Tanzania. Moreover, the author documents causal flows from electricity consumption to economic growth in the country.

Akinlo (2009) considers the nexus in Nigeria for the period 1980-2006. Making use of the Johansen and Juselius (1990) cointegration test, the results highlight the presence of a long-run link between electricity consumption and real GDP. The study also finds causality flowing from electricity consumption to real GDP. In Ghana, Adom (2011) examines the causal link between electricity consumption and economic growth. After establishing a long-run link with the use of the ARDL approach, Toda and Yamamoto (1995) causality test shows that causality runs from electricity consumption to economic growth for the period 1971-2008. In the same vein, Wandji (2013) investigates the relationship between electricity consumption (across several types of energy) and economic growth in Cameroon for the period 1971-2009. The empirical findings do not support causality nexus between electricity consumption and economic growth. Abid and Mraihi (2014) evaluate the relationship between electricity consumption (across several types of energy) and economic growth in Tunisia for the period 1980-2012. They use Johansen et al. (2000) structural break cointegration test and find that cointegration is not present between the series. Further, they show that GDP causes electricity consumption in the short-run.

Looking at studies that have implemented multivariate framework, Bélaïd and Abderrahmani (2013) use annual data from 1971 to 2010 to investigate the causality between electricity consumption and economic growth, while controlling for petroleum prices in the case of the Algerian economy. Using the Johansen and Juselius (1990) test, Gregory and Hansen (1996) test and Granger (1969) causality test, their empirical findings demonstrate the presence of two-way causality between electricity consumption and economic growth. Ouédraogo (2010) adds capital formation to the system to evaluate the nexus in the case of Burkina Faso for the period 1968-2003. The findings reveal the presence of the long-run feedback hypothesis in the case of Burkina Faso. Odhiambo (2009b) includes employment in the nexus for South Africa for the period 1971-2006. The results support the feedback hypothesis in the country. For the case of Kenya, Odhiambo (2010) estimates the causation between electricity consumption and economic growth with labour participation serving as a conditioning variable over the period of 1972-2006. The study finds a distinct unidirectional causal flow running from electricity consumption to economic growth in Kenya. Solarin (2011) uses the ARDL cointegration methodology and Granger causality tests to probe the causal relationship between electricity consumption and national output in Botswana, with capital formation being explicitly added. The author observes the existence of unidirectional causality from electricity consumption to national output. Solarin and Shahbaz (2013) examine the causality between electricity consumption and economic growth in Angola, while urbanisation rate is explicitly included into the system. Both the ARDL bounds test and the Gregory-Hansen test are used to infer cointegration. They provide evidence of bilateral causality between electricity consumption and economic growth. Similarly, Solarin and Bello (2011) probe the electricity-growth nexus for Nigeria with labour force and capital stock serving as conditioning variables in the analysis over the period 1980-2008. Their empirical evidence suggests unidirectional causal flow from electricity consumption to economic growth, thereby, confirming the growth hypothesis.

Solarin (2014) examined the relationship between electricity consumption and economic performance, whilst controlling for capital formation, export and urbanisation in Togo for 1971-2009 period. The findings suggest the existence of long run connection in the variables and a long run positive unidirectional causality is detected from electricity consumption, capital formation and export to economic growth. There is also evidence for long run negative unidirectional causality from urbanisation to economic growth.

3. METHODOLOGY

3.1. Data and Modeling Approach

We apply Cobb–Douglas type production function to test the electricity-growth nexus by adding electricity consumption, urbanization, exports and imports as potential contributory factors in Angola. The supply-side approach is followed by using Cobb–Douglas production (Solarin and Ozturk, 2015). The general functional form of the model is given as follows:

$$Y_t = A_t K_t^{\alpha} L_t^{\beta} E_t^{\delta} U_t^{\gamma} EX_t^{\lambda} IM_t^{\kappa} \mu_t \quad (1)$$

Where, A_t, K_t, L_t, E_t, U_t, EX_t and IM_t is technology level, capital stock, energy use, urbanization, exports and imports respectively. α, β, δ, γ, λ, and κ are elasticity parameters with respective to technology, capital, electricity consumption, urbanization, exports and imports respectively.

Keeping the level of technology constant (Stern, 2011), we utilize total population to transform all the variables into per capita units following Shahbaz et al. (2013). The role of capita in production function is held constant to avoid multicollinearity as we include exports and imports as additional determinants of economic growth (Shahbaz et al. 2016)[1]. We have linearized the production function by transforming all the factors of production into logarithmic form in line with the work of Islam et al. (2013).

1 Another reason for dropping capital formation in this study is because of its insignificance in the economy. One of the most salient features of the Angolan economy is its very low levels of both public and private investments.

The linear Cobb–Douglas production function is constructed as following:

$$\ln Y_t = \alpha_1 + \alpha_2 \ln E_t + \alpha_3 \ln U_t + \alpha_4 \ln EX_t + \alpha_5 \ln IM_t + D_t + \mu_i \quad (2)$$

Where, $\ln Y_t$ is the natural log of real GDP per capita, $\ln E_t$ is the natural log of electricity consumption per capita, $\ln U_t$ is the natural log of urbanization rate, $\ln EX_t$ is the natural log of real exports per capita, $\ln IM_t$ is the natural log of real imports per capita, D_t is a dummy variable to capture the structural breaks in real GDP per capita and μ_i is the error term, with the assumption of normal distribution. Moreover, urbanisation, imports and exports are selected due to availability of the data, theoretical justification and justification from previous studies.

The data of real GDP per capita (2005=100), electricity consumption per capita (measured in million kWh per capita), urbanization rate (urbanization divided by total population), real exports of goods and services per capita (2005 = 100) and real imports of goods and services per capita (2005 = 100) for the period 1971-2012 are sourced from the World Bank Development Indicators of the World Bank[2].

The inclusion of exports into the nexus is primarily based on the export-led hypothesis. According to the hypothesis, rising exports of goods and services will lead to productivity growth and economy-wide efficiency. The expansion of exports can promote economic growth both directly, as an element of aggregate demand, and indirectly through greater capacity utilization, efficient allocation of the resources, enhancement of economies of scale and technological spillovers. Theoretically, exports can engender energy in several ways. Machineries and equipments- which are usually propelled by energy to operate- are used in loading and transporting exports to airports, seaports or other outbound points. An expansion in exports of goods and services symbolizes an expansion in economic activity and therefore a rise in exports should boost the energy demand. There is also the possibility that changes in energy will influence exports of goods and services because it is a key factor of production. Exporting raw materials or final goods depends on fuel transportation. In the absence of sufficient oil for transportation purposes, expansion of exports will be adversely influenced. In this case, energy conservation agenda may negatively affect the ability to transport exports. As a result, energy is a key factor of export expansion and adequate usage of energy is essential to enhancing exports of goods.

The relationship between imports and economic activities is not as clear-cut as the connection between exports and economic activities. On the one hand, imports of machineries and equipment are expected to generate technological spillovers which will accelerate economic development. On the other hand, competing imports will have little impact on productivity growth, if the import is meant for a sector that is technologically undeveloped as weak companies are unable to compete with their more sophisticated

2 It is the longest time period considered to examine the causal relationship between energy consumption and economic growth in Africa.

foreign counterparts. In other words, in an environment where adequate protection for local infant industries does not exist, excessive imports, especially through dumping may lead to closures of local businesses. In this case, imports of goods and services are expected to have negative impact on economic growth. Similarly, energy and imports might have two-way relationships. Imports can promote the intensity of energy usage if the imports are mainly durable goods including automobiles, air conditioners, and refrigerators. Channelling imported goods, especially durable energy intensive goods into various locations within a country will be difficult if there is insufficient availability of energy. On the other hand, imports might have dampened impact on energy usage in a country and vice versa. For instance, imports may lead to closures of local businesses, which may lead to less demand for energy.

Although its exact impact (positive or negative) still remains a burning issue, urbanization is a major feature of economic development, especially in the developing countries, where the pace of urbanization is most significant. In developing countries, urbanization triggers several structural shifts throughout the economy and has vital implication on electricity consumption. The increase in economic activities, resulting from urbanization causes the demand for energy (including electricity) consumption to rise (Solarin and Shahbaz, 2013). Several authors have added these control variables in their studies of the relationship between energy and economic activities (Narayan and Smyth, 2009; Lean and Smyth, 2010). Urbanization may affect electricity consumption by providing access of urban people to electrical appliances compared to rural population. Furthermore, urbanization affects electricity consumption resulting from increase in demand for public utilities, industrialization and globalization among others (Shahbaz and Lean, 2012).

3.2. Fourier Augmented Dickey Fuller (FADF) Unit Root Test

To accommodate unknown structural breaks and nonlinearities in the time series, we examine the unit root properties of the variables through the ADF test in the Fourier domain (Enders and Lee, 2012)[3]. A selected Fourier function frequency component is used to estimate the deterministic component of the model. The test avoids the problem of power loss resulting from the use of too many dummy variables (Enders and Lee, 2012). The nonlinear FADF statistic (τ_{DF}) can be specified as:

$$\Delta y_t = \rho y_{t-1} + c_0 + \gamma_1 \sin\left(\frac{2\pi kt}{T}\right) + \gamma_2 \cos\left(\frac{2\pi kt}{T}\right) + \sum_{i=1}^{l} c_i \Delta y_{t-i} + e_t \quad (3)$$

In Equation (1), $k, \gamma, t,$ and T denote the frequency, the parameter of the Fourier approximation, the trend term, and the number of observations, respectively; and $\pi = 3.1416$. Notably, the standard ADF unit root test is a special case of FADF when the trigonometric terms are set to zero (i.e., $\gamma_1 = \gamma_2 = 0$). Inclusion of trigonometric terms (the null hypothesis of linearity) into the model is examined through the usual F-statistic (Enders and Lee, 2012). The FADF statistic (τ_{DF}) depends on the frequency (k) and the lag length (l). Enders and Lee (2012) suggest that a Fourier function with $k = 1$ or $k = 2$ will provide a reasonable approximation to capture unknown structural breaks. Hence, the maximum frequency ($k_{\max}$) is set to 2 and the optimal frequency ($\tilde{k}$), i.e., the frequency to obtain the smallest SSR among the different specifications, is selected through a data-driven method. The optimal lag length ($\tilde{l}$) is selected based on Akaike information criterion (AIC). A nonlinear FADF test would be appropriate if the null hypothesis of linearity is rejected, and the standard linear test can be used otherwise (Enders and Lee 2012).

3 We are thankful to the anonymous referee for recommending Fourier unit root test.

3.3. The Bayer–Hanck Cointegration Approach

The existing econometric literature reveals that the linear combination of series has lower order of integration if the time series are integrated at I(1) or (2). Engle and Granger (1987) pioneer the cointegration approach to examine long-run relationships between the series. The test requires all the series to be stationarity at the same level. The Engle-Granger cointegration approach is suitable when the data sets turn out to be of a finite size. However, this approach provides biased results due its low explanatory power. In the late 1980s, Johansen (1988) introduced a new test of cointegration, the Johansen maximum eigenvalue test, preferred by the researchers because it permits the presence of more than one cointegrating relationships between the variables.

The error correction model (ECM)-based F-test, developed by Boswijk (1995) and the ECM based *t*-test, developed by Banerjee et al. (1998) are also commonly used to ascertain the cointegration between the variables. The Bayer and Hanck, (2013) cointegration approach combines different tests (which ordinarily yield different conclusions) into a single framework. The null of no-cointegration in the Bayer and Hanck (2013) approach is based on the Engle and Granger (1987), Johansen (1988), Boswijk (1995) and Banerjee et al. (1998) tests. In particular, the Bayer and Hanck (2013) framework jointly determines test-statistics of the Engle and Granger (1987), Johansen (1988), Boswijk (1995) and Banerjee et al. (1998) tests. We apply this approach to examine whether cointegration is present between electricity consumption and economic growth in Angola. The combination of the estimated significance level (P-value) of each cointegration test in Fisher's formulas is presented as follows:

$$EG-JOH=-2[\ln(p_{EG})+(p_{JOH})] \quad (4)$$

$$EG-JOH-BO-BDM=-2[\ln(p_{EG})+(p_{JOH})+(p_{BO})+(p_{BDM})] \quad (5)$$

Where p_{EG}, p_{JOH}, p_{BO}, and p_{BDM} are the P-values of the Engle and Granger (1987), Johansen (1988), Boswijk (1995) and Banerjee et al. (1998) tests, respectively. It is premised on the assumption that if the computed Fisher statistics is more than the critical values generated by Bayer and Hanck, (2013), we can reject the null hypothesis of no cointegration.

3.4. The VECM Granger Causality Approach

After the examination of the long-run relationship between the variables, we use the Granger causality test to estimate the causal relations between the series. If cointegration exists in the series, then the VECM can be specified as follows:

$$\begin{bmatrix} \Delta \ln Y_t \\ \Delta \ln E_t \\ \Delta \ln U_t \\ \Delta \ln EX_t \\ \Delta \ln IM_t \end{bmatrix} = \begin{bmatrix} b_1 \\ b_2 \\ b_3 \\ b_4 \\ b_5 \end{bmatrix} + \begin{bmatrix} B_{11,1} & B_{12,1} & B_{13,1} & B_{14,1} & B_{15,1} \\ B_{21,1} & B_{22,1} & B_{23,1} & B_{24,1} & B_{25,1} \\ B_{31,1} & B_{32,1} & B_{33,1} & B_{34,1} & B_{35,1} \\ B_{41,1} & B_{42,1} & B_{43,1} & B_{44,1} & B_{45,1} \\ B_{51,1} & B_{52,1} & B_{53,1} & B_{54,1} & B_{55,1} \end{bmatrix} \times \begin{bmatrix} \Delta \ln Y_{t-1} \\ \Delta \ln E_{t-1} \\ \Delta \ln U_{t-1} \\ \Delta \ln EX_{t-1} \\ \Delta \ln IM_{t-1} \end{bmatrix} + \ldots + \begin{bmatrix} B_{11,m} & B_{12,m} & B_{13,m} & B_{14,m} & B_{15,m} \\ B_{21,m} & B_{22,m} & B_{23,m} & B_{24,m} & B_{25,m} \\ B_{31,m} & B_{32,m} & B_{33,m} & B_{34,m} & B_{35,m} \\ B_{41,m} & B_{42,m} & B_{43,m} & B_{44,m} & B_{45,m} \\ B_{51,m} & B_{52,m} & B_{53,m} & B_{54,m} & B_{55,m} \end{bmatrix} \times \begin{bmatrix} \Delta \ln Y_{t-1} \\ \Delta \ln E_{t-1} \\ \Delta \ln U_{t-1} \\ \Delta \ln EX_{t-1} \\ \Delta \ln IM_{t-1} \end{bmatrix} + \begin{bmatrix} \delta_1 \\ \delta_2 \\ \delta_3 \\ \delta_4 \\ \delta_5 \end{bmatrix} \times (D_t) + \begin{bmatrix} \zeta_1 \\ \zeta_3 \\ \zeta_3 \\ \zeta_4 \\ \zeta_5 \end{bmatrix} \times (ECM_{t-1}) + \begin{bmatrix} \mu_{1t} \\ \mu_{2t} \\ \mu_{3t} \\ \mu_{4t} \\ \mu_{5t} \end{bmatrix} \tag{6}$$

Where the difference operator is Δ and ECM_{t-1} is the lagged error correction term, generated from the long-run equation. D_t is the dummy variable. The t-statistic of the lagged error correction terms is used to determine the causality in the long-run. The short-run causality relationship is confirmed by the statistical significance of Chi-square for differences across the variables. For example, $B_{12,i} \neq 0 \forall_i$ shows that electricity consumption Granger causes economic growth, while economic growth Granger causes electricity consumption if $B_{21,i} \neq 0 \forall_i$.

4. EMPIRICAL RESULTS AND DISCUSSION

The cointegration tests require information on the order of integration of variables because cointegration approaches are sensitive to the order of integration. The traditional unit root tests may wrongly reject the null hypothesis in the presence of structural breaks due to their weak explanatory powers. Therefore, we first use the Perron (1997) unit root test, which incorporates an endogenously determined structural break point and the results are reported in Table 1.

The results show that electricity consumption ($\ln E_t$), economic growth ($\ln Y_t$), urbanization ($\ln U_t$), exports ($\ln EX_t$) and imports ($\ln IM_t$) have a unit root. Most of the structural breaks occurred when the country was embroiled in the civil war of 1975-2002. For instance, Angola held elections in 1992 which were rejected by opposition parties. At first differences, all series are found to be stationary. To further assure the presence of nonlinearities and the unit root properties of the variables in the presence of multiple breaks and nonlinearities, we utilize the FADF test, as described in the methodology section. The results of FADF unit root test are reported in Table 2. The F-statistic fails to reject the null hypothesis of linearity for all the time series and the FADF (τ_{DF}) test statistics fails to reject the null hypothesis of unit root. In the absence of nonlinearity, we resort back to our finding of Perron (1997) and conclude that variables are linear and I(I).

Both unit root test results show that all the variables are characterized as I(1) variables. In this case, the combined cointegration test developed by Bayer and Hanck (2013) is suitable to examine whether cointegration exists or not. Table 3 presents the combined cointegration tests, namely, the EG-JOH and the EG-JOH-BO-BDM test statistics. We find that Fisher-statistics for EG-JOH and EG-JOH-BO-BDM tests exceed the critical values at the 5% level of significance or better and therefore rejects the null hypothesis of no cointegration among the variables. We may conclude that there is a long-run relationship between economic growth, urbanization, exports and imports over the period of 1971-2012 in the case of Angola.

Bayer and Hanck (2013) combined cointegration approach provides efficient empirical results but fails to accommodate structural breaks This issue is resolved by applying the ARDL bounds testing approach with structural breaks, following Shahbaz et al. (2013). The ARDL bounds test is sensitive to the lag length selection; to this end, we make use of the AIC to select the appropriate lag order of the variables. It is reported by Lütkepohl, (2006) that the dynamic association between the

Table 1: Unit root analysis

Variable	Perron (1997) at level		Perron (1997) at 1st difference	
	T-statistic	Time break	T-statistic	Time break
$\ln Y_t$	−3.286 (0)	1992	−6.041 (0)**	1993
$\ln E_t$	−3.432 (0)	1991	−7.473 (1)***	1979
$\ln U_t$	−3.714 (1)	1985	−5.520 (0)*	1995
$\ln EX_t$	−4.171 (0)	1994	−9.312 (2)***	2004
$\ln IM_t$	−3.431 (0)	1998	−9.689 (0)***	1992

***,**,*Imply 1%, 5% and 10% levels of significance. The critical vales are−6.32, −5.32 and 5.29 for 1%, 5% and 10% level of significance, respectively. () is the optimal lag length

Table 2: Results of nonlinear FADF unit root test

Variables	$\tilde{k}$	SSR	$\tilde{l}$	AIC	F ($\tilde{k}$)	τ_{DF}
$\ln Y_t$	1	0.2492	4	−1.7297	5.1710	−2.5027
$\ln E_t$	1	0.2694	5	−1.4704	2.3764	−0.6959
$\ln U_t$	1	0.0004	6	−9.8592	5.5777	−3.1741
$\ln EX_t$	2	2.4446	1	0.2928	2.1499	−0.4115
$\ln IM_t$	2	2.2037	0	0.1095	1.4054	0.3753

In nonlinear FADF unit root test, the optimal frequency ($\tilde{k}$) is selected by using the data-driven grid-search method in which the frequency minimizes the SSR from equation (XX). The optimal lag ($\tilde{l}$) is the lag length that minimizes the Akaike information criterion (AIC). The critical values are obtained from Table 1 in Enders and Lee (2012). FADF: Fourier augmented Dickey Fuller variables can be captured if the suitable lag length is chosen. The results are reported in Table 4. We use the critical bounds from Narayan (2005) to reach a decision on the presence of cointegration. The results display that the ARDL F-statistic is greater than the upper critical bound when we use electricity consumption, economic growth, exports and imports as dependent variables. The ARDL bounds testing analysis confirms our established long-run association across the series under investigation.

After confirming that the cointegration between the variables, we examine the long- and short-run impact of electricity consumption, urbanization, exports and imports on economic growth. The long-run results are presented in Table 5. Electricity consumption has a positive impact (significant at 1% level) on real GDP per capita. A 1% increase in electricity consumption increases economic growth by 0.4880%, keeping other things constant, which validates the energy-led growth hypothesis. Keeping other things constant, a 1% increase in urbanization reduces economic growth by 0.7749%. The impact of exports on economic growth is positive (0.3859), thereby, validating the exports-led growth hypothesis. The impact of imports on economic growth is negative (−0.1758) and statistically significant at the 10% level of significance. The structural break dummy is also statistically significant at 10%. It can be inferred that the rejection of general electrician held in 1992 by the opposition had a negative impact on the economic growth.

The short-run results are shown in the lower panel of Table 5. It is documented that energy consumption increases economic growth while the impact of urbanization on economic growth is negative. The exports (imports) increase (decrease) the economic growth in the short-run as well. The structural break does not have a significant impact on economic growth, in the short-run. The negative and statistically significant estimate of ECM_{t-1}(−0.5173) support the long-run relationship between the variables. The short-run deviations from the equilibrium are corrected by 51.73% towards the long-run equilibrium path each year. The diagnostic tests show that there is no problem of heteroskedasticity or serial correlation, and the error terms are normally distributed. The Ramsey reset test show that the model is well specified in the functional form.

The cointegration between the time series implies some forms of causal relationships. We investigate this relationship within the framework of the VECM. Table 6 reports the results of long- and short-run causality and indicate the presence of a bidirectional causality between electricity consumption and economic growth in the long-run. The causal nexus between exports (imports) and economic growth is also bidirectional, while urbanization Granger causes economic growth, electricity consumption, exports and imports. Moreover, there is a feedback effect between imports and exports in the long-run. In the short-run, electricity consumption Granger causes economic growth, while the feedback effect is also confirmed between exports and economic growth. Economic growth leads to higher urbanization, while exports Granger cause urbanization; at the same time, the feedback is present indicating that urbanization Granger causes exports. Bidirectional causality also exists between imports and economic growth. Finally, urbanization Granger causes imports.

The empirical findings of long-run bidirectional causality between electricity consumption and economic growth are consistent with those provided by Jumbe (2004) for the case of Malawi; Odhiambo (2010) for the case of Kenya; Ouédraogo (2010) for the case of Burkina Faso; Bélaïd and Abderrahmani (2013) for the case of Algeria; and Solarin and Shahbaz (2013)

Table 3: The results of Bayer and Hanck cointegration analysis

Estimated models	EG-JOH	EG-JOH-BO-BDM	Cointegration
$\text{In}Y_t=f(\ln E_t, \ln U_t, \ln EX_t, \ln IM_t)$	17.328***	28.553**	Yes
$\ln E_t=f(\ln Y_t, \ln U_t, \ln EX_t, \ln IM_t)$	20.132***	26.852**	Yes
$\ln U_t=f(\ln Y_t, \ln E_t, \ln EX_t, \ln IM_t)$	3.765	7.705	No
$\ln EX_t=f(\ln Y_t, \ln E_t, \ln U_t, \ln IM_t)$	14.302**	20.668**	Yes
$\ln IM_t=f(\ln Y_t, \ln E_t, \text{In}U_t, \ln EX_t)$	14.720**	36.180***	Yes

***,**Imply 1% and 5% levels of significance, respectively. Critical values at 10%, 5% and 1% levels are 8.301, 10.576, 15.845 for (EG-JOH) and 15.938, 20.143, 30.774 for (EG-JOH-BO-BDM) respectively

Table 4: The ARDL cointegration analysis

Estimated models	Bounds testing to cointegration			Diagnostic tests		
	Lag length	Structural break	F-statistics	χ^2_{NORMAL}	χ^2_{ARCH}	χ^2_{RESET}
$\text{In}Y_t=f(\ln E_t, \ln U_t, \ln EX_t, \ln IM_t)$	2, 2, 2, 1, 2	1992	36.669***	0.1409	0.3658	0.1258
$\ln E_t=f(\ln Y_t, \ln U_t, \ln EX_t, \ln IM_t)$	2, 2, 1, 1, 2	1991	9.384***	0.3661	0.0773	0.4605
$\ln U_t=f(\ln Y_t, \ln E_t, \ln EX_t, \ln IM_t)$	2, 2, 2, 2, 2	1985	1.426	5.878	0.0036	0.1200
$\ln EX_t=f(\ln Y_t, \ln E_t, \ln U_t, \ln IM_t)$	2,1, 1, 1, 2	1994	7.979***	0.8676	0.0003	0.3436
$\ln IM_t=f(\ln Y_t, \ln E_t, \text{In}U_t, \ln EX_t)$	2, 2, 2, 2, 2	1998	12.395***	0.3291	0.0014	0.2664
Significant level	Critical values (T=42)#					
	Lower bounds $I(0)$	Upper bounds $I(1)$				
1% level	6.053	7.458				
5% level	4.450	5.560				
10% level	3.740	4.780				

***Imply 1% level of significance. The optimal lag length is determined by AIC. #Critical values are obtained from Narayan (2005) for the case of Angola. However, they are different from those provided by Solarin and Shahbaz (2013), in the sense that ours do not find any evidence of causality running from either economic growth or electricity consumption towards urbanization in the long-run.

As the Granger causality method is not able to explain anything out of the selected time period, we augment the analysis with the error variance decomposition method (VDM) approach as recommended by Pesaran and Shin (1998). The method shows the degree of the predicted error variance for a variable resulting from innovations of the exogenous series over different time-horizons beyond the time period under consideration.

The results of the VDM approach, reported in Table 7, reveal that a 90.41% portion of economic growth is explained by its own innovative shocks, while innovative shocks of electricity consumption, urbanization, exports and imports contribute to economic growth by 4.84%, 1.84%, 0.83% and 2.06%, respectively. These variables through their own shocks contribute to electricity consumption by 2.44%, 1.17% and 0.71%, respectively. The contribution of economic growth to electricity consumption is 88.69%, while economic growth contributes to urbanization by 72.86%; 0.55% is explained by innovative shocks, which occur in electricity consumption. Exports and imports contribute to urbanization by 1.12% and 1.13%, respectively. Economic growth, electricity consumption, urbanization and imports explain exports by 61.53%, 10.43%, 3.18% and 8.33%, respectively. The share of economic growth, electricity consumption, urbanization and exports to imports is 55.84%, 12.98%, 3.61% and 12.02%, respectively.

The results of impulse response function are reported in Figure 1. We use the generalized impulse response approach which is superior to the "orthogonalized" impulse responses. The generalized impulse response approach is insensitive to the order of vector autoregression (VAR) variables (Hurley, 2010). The Figure 1 shows that responses of electricity consumption are positive, but urbanization responds negatively due to innovative shocks stemming in economic growth. Moreover, the response of exports and imports is also positive, while economic growth, exports and imports (urbanization) respond positively (negatively) due to shocks arising in electricity consumption. Moreover, the response of economic growth, electricity consumption, exports and imports is negative to shocks from urbanization. Finally, the response of electricity consumption and urbanization is fluctuating due to innovative shocks occurring in both exports and imports. Overall, these results do not change the gist provided by the causality tests.

Table 5: Long run and short run analysis

Dependent variable = $\ln Y_t$				
Long run analysis				
Variables	**Coefficient**	**Standard error**	**T-statistic**	**P-values**
Constant	6.0415***	0.2864	21.0908	0.0000
$\ln E_t$	0.4880***	0.0695	7.0149	0.0000
$\ln U_t$	−0.7449***	0.0903	−8.2468	0.0000
$\ln EX_t$	0.3859***	0.0953	4.0457	0.0003
$\ln IM_t$	−0.1758*	0.0984	−1.7867	0.0826
D_{1992}	−0.1001*	0.0588	−1.7036	0.0971
Short run analysis				
Variables	**Coefficient**	**T-statistic**	**Coefficient**	**T-statistic**
Constant	0.0325	0.0351	0.9258	0.3612
$\ln E_t$	0.2809***	0.0608	4.6162	0.0001
$\ln U_t$	−1.7994**	0.8758	−2.0544	0.0479
$\ln EX_t$	0.2848***	0.0705	4.0367	0.0003
$\ln IM_t$	−0.0279	0.0788	−0.3546	0.7251
D_{1992}	−0.0844	0.0701	−1.2032	0.2372
ECM_{t-1}	−0.5173***	0.1502	−3.4431	0.0016
R^2	0.4619			
F-statistic	5.6656***			
D.W	1.7504			
Short run diagnostic tests				
Test	**F-statistic**	**P-value**		
χ^2_{NORMAL}	0.9117	0.6338		
χ^2_{SERIAL}	0.9898	0.3830		
χ^2_{ARCH}	0.0084	0.9271		
χ^2_{WHITE}	1.0694	0.4166		
χ^2_{RAMSEY}	1.4278	0.1103		
CUSUM	Stable	0.0500		
CUSUMsq	Stable	0.0500		

***,**,*Imply 1%, 5% and 10% levels of significance, respectively. ECM: Error correction method

Table 6: The VECM Granger causality analysis

Dependent variable	Direction of causality											
	Short run					Long run	Joint long-and-short run causality					
	$\Delta \ln Y_{t-1}$	$\Delta \ln E_{t-1}$	$\Delta \ln U_{t-1}$	$\Delta \ln IM_{t-1}$	$\Delta \ln EX_{t-1}$	ECT_{t-1}	Break year	$\Delta \ln Y_{t-1}$, ECT_{t-1}	$\Delta \ln E_{t-1}$, ECT_{t-1}	$\Delta \ln U_{t-1}$, ECT_{t-1}	$\Delta \ln IM_{t-1}$, ECT_{t-1}	$\Delta \ln EX_{t-1}$, ECT_{t-1}
$\Delta \ln Y_t$	-	3.2005*	1.1203	3.2388*	16.100***	−0.9069***	1992	-	4.8161***	5.2387***	5.8307***	14.7402***
		[0.0565]	[0.3409]	[0.0645]	[0.0000]	(−3.4778)			[0.0085]	[0.0056]	[0.0035]	[0.0000]
$\Delta \ln E_t$	0.6732	-	2.9056*	0.1241	0.6670	−0.4789**	1991	3.6288**	-	5.9083***	3.6868**	6.1060***
	[0.5183]		[0.0738]	[0.8831]	[0.5074]	(−2.7071)		[0.0511]		[0.0034]	[0.0540]	[0.0032]
$\Delta \ln U_t$	3.2964*	6.3223***	-	1.0247	4.3563**	….	1985	-	-	-	-	-
	[0.0518]	[0.0054]		[0.3720]	[0.0225]							
$\Delta \ln IM_t$	4.0328**	0.3070	1.2145	-	26.400***	−0.8435***	1994	6.3017***	5.2107***	8.8400***		20.1240***
	[0.0312]	[0.7312]	[0.3145]		[0.0000]	(−3.5400)		[0.0022]	[0.0058]	[0.0004]		[0.0000]
$\Delta \ln EX_t$	3.9882**	1.0614	3.6709**	23.974***	-	−0.7403***	1998	6.6519***	5.2111***	6.8110***	17.4742***	-
	[0.0492]	[0.3599]	[0.0510]	[0.0000]		(−3.9764)		[0.0017]	[0.0063]	[0.0015]	[0.0000]	

***,**,*Show significance at 1%, 5% and 10% levels, respectively. () and [] refer to the t-statistics and prob-values

Table 7: Variance decomposition method (VDM)

Period	$\ln Y_t$	$\ln E_t$	$\ln U_t$	$\ln EX_t$	$\ln IM_t$
Variance decomposition of $\ln Y_t$					
1	100.0000	0.0000	0.0000	0.0000	0.0000
3	93.6566	2.2828	0.2330	0.3979	3.4295
5	90.1567	5.8507	0.2040	0.4081	3.3802
7	89.0908	6.6969	0.3253	0.8633	3.0235
9	89.2946	6.1038	1.0705	0.8086	2.7222
11	89.4701	5.5518	1.7336	0.8024	2.4418
13	89.6927	5.1750	1.9821	0.8699	2.2800
15	89.9603	4.9404	2.0023	0.9000	2.1968
16	90.0812	4.8753	1.9761	0.8965	2.1706
17	90.1865	4.8415	1.9415	0.8843	2.1459
18	90.2762	4.8310	1.9053	0.8678	2.1195
19	90.3529	4.8341	1.8712	0.8503	2.0913
20	90.4197	4.8425	1.8409	0.8340	2.0627
Variance decomposition of $\ln E_t$					
1	10.4863	89.5136	0.0000	0.0000	0.0000
3	76.0237	18.7093	0.3882	3.5212	1.3574
5	81.5939	12.7165	2.4281	2.2621	0.9990
7	84.0434	10.4179	2.9120	1.8176	0.8090
9	85.5736	9.0757	3.0621	1.6009	0.6875
11	86.6561	8.1146	3.0529	1.5021	0.6740
13	87.3836	7.5667	2.9054	1.4265	0.7175
15	87.9131	7.2821	2.7347	1.3373	0.7326
16	88.1217	7.1894	2.6604	1.2962	0.7321
17	88.2993	7.1159	2.5953	1.2598	0.7295
18	88.4508	7.0559	2.5388	1.2283	0.7259
19	88.5807	7.0056	2.4899	1.2013	0.7222
20	88.69294	6.962209	2.4474	1.1784	0.7189
Variance decomposition of $\ln U_t$					
1	1.0498	11.1153	87.8347	0.0000	0.0000
3	39.4504	2.2877	47.0084	8.3883	2.8650
5	41.7051	1.1944	45.1060	5.9750	6.0193
7	43.3410	0.6864	46.3184	3.2132	6.4409
9	46.9176	0.8163	45.1824	2.0465	5.0369
11	52.1444	0.8067	41.6184	1.8731	3.5572
13	57.9774	0.6212	37.0073	1.8215	2.5723
15	63.4286	0.4872	32.4899	1.6440	1.9501
16	65.8151	0.4669	30.4649	1.5297	1.7232
17	67.9388	0.4721	28.6387	1.4150	1.5353
18	69.8056	0.4935	27.0149	1.3075	1.3782
19	71.4373	0.5228	25.5824	1.2112	1.2461
20	72.8628	0.5541	24.3214	1.1273	1.1341
Variance decomposition of $\ln EX_t$					
1	31.7512	0.4459	3.6501	64.1526	0.0000
3	41.4736	8.1719	2.1928	39.8674	8.2940
5	50.8395	7.0829	2.3394	26.6330	13.1050
7	54.0112	10.3242	3.3600	21.1256	11.1788
9	55.8065	11.7328	3.2200	19.4918	9.7488
11	57.5778	11.6534	3.0558	18.5032	9.2095
13	58.9418	11.2558	3.1981	17.7258	8.8783
15	59.9230	10.9114	3.3045	17.2529	8.6080
16	60.3290	10.7674	3.3003	17.0891	8.5140
17	60.6940	10.6428	3.2713	16.9414	8.4502
18	61.0189	10.5432	3.2352	16.7953	8.4073
19	61.3002	10.4731	3.2050	16.6482	8.3732
20	61.5359	10.4326	3.1862	16.5055	8.3395
Variance decomposition of $\ln IM_t$					
1	19.0631	0.7608	0.0000	31.4277	48.7483
3	29.9114	19.0901	3.5690	24.9112	22.5181

(Contd...)

Table 7: *(Continued)*

Period	$\ln Y_t$	$\ln E_t$	$\ln U_t$	$\ln EX_t$	$\ln IM_t$
5	43.1666	11.0180	2.2577	18.7031	24.8543
7	47.0455	12.9111	3.5728	14.6409	21.8295
9	49.2173	14.3732	3.9146	13.7464	18.7483
11	51.4000	14.3611	3.6216	13.2939	17.3232
13	52.9918	13.9724	3.6226	12.7820	16.6311
15	54.0870	13.5923	3.7137	12.4393	16.1674
16	54.5293	13.4301	3.7257	12.3363	15.9784
17	54.9229	13.2844	3.7097	12.2580	15.8247
18	55.2731	13.1581	3.6775	12.1861	15.7049
19	55.5804	13.0570	3.6441	12.1094	15.6089
20	55.8431	12.9845	3.6195	12.0270	15.5256

ARDL: Autoregressive distributed lag, VECM: Vector error correction method

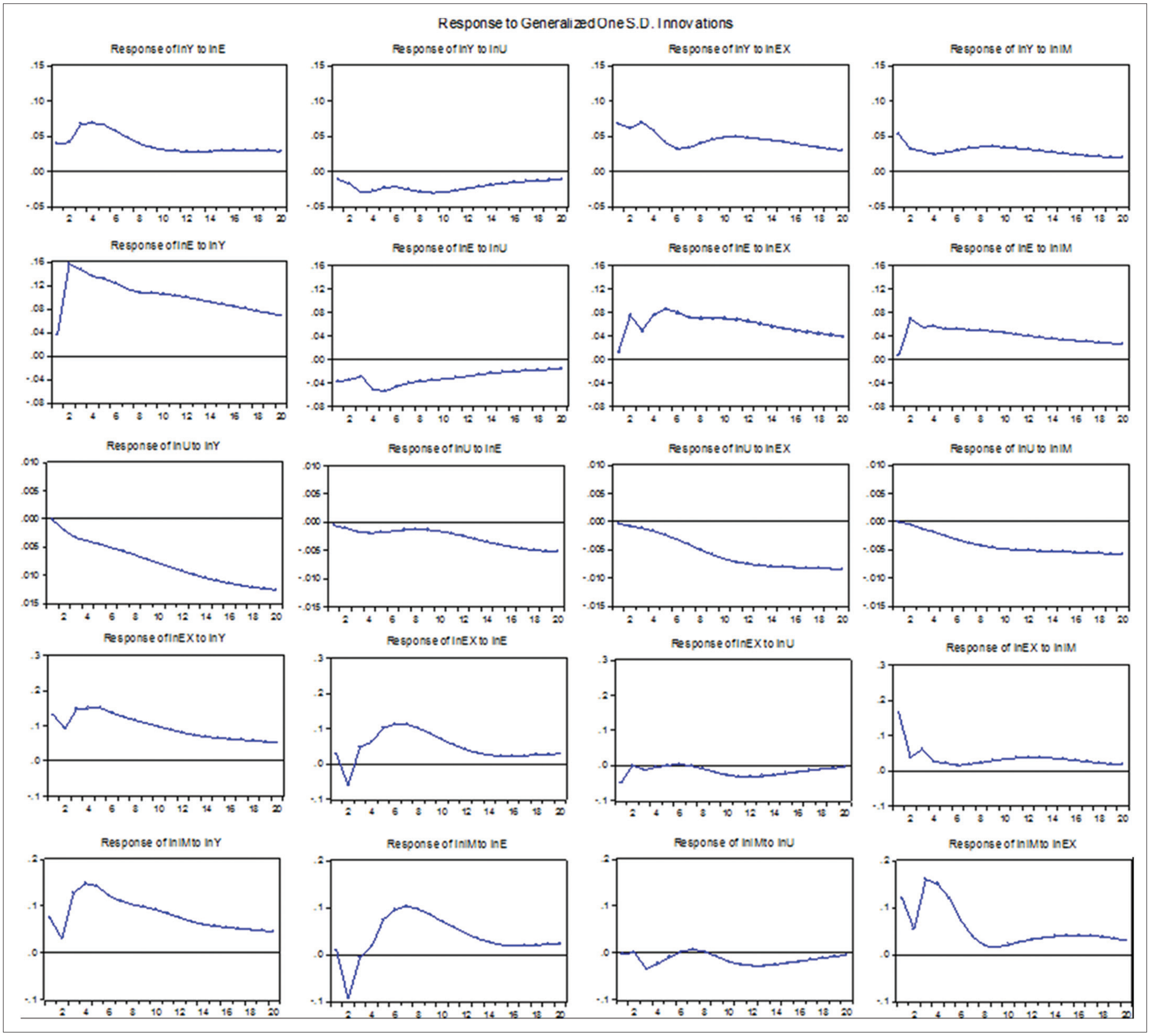
5. CONCLUSIONS AND POLICY IMPLICATIONS

This paper revisited the electricity-growth nexus in Angola by incorporating urbanization, exports and imports as major contributing factors. The time span of the present study is 1971-2012. We use the combined cointegration approach to examine the long-run relationship between the variables. The VECM Granger causality approach is used to test the causal relationship and out of sample causality was examined by applying error variance decomposition (VDM) approach. The results confirm that cointegration is present between the variables. Electricity consumption increases economic growth. Imports and urbanization decrease economic growth, while exports boost economic activity. The VECM Granger causality results suggested that the casual flows between electricity consumption and economic growth are bidirectional. The two-way casual nexus also exists between exports (imports) and electricity consumption. Further, urbanization Granger causes electricity consumption, economic growth, exports and imports.

The bidirectional causality between electricity consumption and economic growth implies that though energy policies tailored towards advancing energy efficiency are appropriate in achieving considerable benefits from electricity usage, the adoption of polices to conserve the use of electricity is expected to limit the Angolan domestic production. In such situation, any shortage of the electricity supply will also retard economic growth. Moreover, reductions in output will adversely affect the demand for electricity activities in return. Shocks to one of these variables are expected to pass to the other and the chain will persist via the feedback effect. Therefore, expansionary electricity policies are beneficial for the economy of Angola.

Given the present scenario of electricity shortages, constant darkness and interruptions that are common in the country, the aims of realizing prompt economic growth and establishing the country as one of the top developing economies might not be easy to attain. The problem of electricity shortage would adversely affect the country's social and economic progress. It is, therefore, suggested that the government should concentrate its efforts on improving the electricity supply. With estimated hydroelectricity potentials of 18,000 mw, the execution of these policies should

Figure 1: Impulse response function



not be difficult for the authorities. Beyond hydroelectricity, the country should exploit the opportunities of other sources of renewable energy for electricity supply to make sure that there is reliable and uninterrupted energy availability. The development of other sources of energy, such as biofuel and solar energy may help in attaining this goal.

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