MULTIVARIATE CAUSALITY TEST OF ELECTRICITY CONSUMPTION, CAPITAL FORMATION, EXPORT, URBANISATION AND ECONOMIC GROWTH FOR TOGO

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ABSTRACT
This study examines the electricity consumption and economic growth relationship in Togo for 1971- 2009 period. Controlling for capital formation, export and urbanisation, findings suggest the existence of long run connection in the variables. The study further detects long run positive unidirectional causality from electricity consumption, capital formation and export to economic growth, with long run negative unidirectional causality from urbanisation to economic growth. These indicate that expansive energy policies are necessary for sustainable increment in the national output of Togo. However, expansive policies must be complemented with improvement of capital formation; development of the export industry; and taming the pace of urbanisation in the country.

Keywords:
Electricity consumption; Economic growth, Export, Capital formation, Urbanisation, Togo

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1. INTRODUCTION

One obvious feature of modernity is the robust and consistent upsurge in the usage of energy. Majority of the supply shocks that affected the world economies in the latter half of the last century resulted from disruptions (or changes) in the supply of energy products (Abel, Brenanke and Croushore, 2011)[1]. Among other issues, such incidents have attracted the attention of energy economists to scrutinize the degree at which energy influences economic activities. Commencing with the seminal paper of Kraft and Kraft (1978), the literature has largely applied causality tests in exploring the significance of energy consumption (and electricity consumption). In the process, four types of causations have been identified. First, causation flowing from energy consumption towards the economy is depicted as evidence of energy usage influencing economic activity, which also implies expansive energy policies are compatible with economic progression. Restrictions in the usage of energy may harmfully affect economic activity, while upsurges in energy may boost economic activities. Therefore, energy consumption serves as a significant factor of production, alongside capital and labour inputs. Second, causation moving from income to energy consumption denotes economic activity is not reliant on energy utilisation and therefore conservative energy policies should be pursued. Third, two-way causations (which is also called feedback hypothesis) between energy and economic growth suggest economic growth and consumption are interconnected, backing expansionary policies in the energy sector. Lastly, absence of causal link implies finite role for energy consumption on economic growth. In this case, neither energy expansive nor conservative programmes will influence economic growth (Ozturk, 2010).

In the past, a large body of literature concentrated on the relationship between energy consumption (as a unit) and economic growth (see Ghali and El-Sakka, 2004; Glasure, 2002; Ho and Siu, 2007; Oh and Lee, 2004; Payne, 2009; Zamani, 2007; Shahbaz et al., 2013). There are also research that looked into the connection between economic growth and various components of energy such as coal (Kumar and Shahbaz, 2012; Zhang and Li, 2007) and natural gas (Isik, 2010). The subset of energy consumption that received most attention is electricity consumption, with most works on non-African countries (see Chen et al. 2007; Hu and Lin, 2008; Jamil and Ahmad, 2010; Shahbaz and Feridun, 2012; Yoo, 2006). For the African case, papers include Akinlo, 2009; Jumbe, 2004; Odhiambo, 2009a, 2009b, 2010; Solarin, 2011; Solarin and Bello 2011; Solarin, 2012; Squalli, 2007; and Wolde-Rufael, 2006. However, with the exception of Alinsato (2009), there is no published paper on electricity consumption and economic growth for the case of Togo.

Togo is a country, which is on the one hand faced with perennial electricity shortage and on the other hand, economic stagnation. The rise of electricity consumption has not been marched by a corresponding increase in electricity production. In Figure, 1, it is shown that electricity consumption was 64.12 kWh per capita in 1980 and rose to 93.57 kWh per capita in 1990 and 97.84 kWh per capita in 2000 and further increased to 110.81 kWh per capita in 2009. Correspondingly, electricity production was 19.123 kWh per capita in 1980, rose

1 These include the energy crises of 1973-74 (triggered by oil-embargo of Organisation of Petroleum Exporting Countries (OPEC); the inadequacy of suppliers to meet the demand for energy of countries such as India and China in the period of 2003-2008.

to 43.10 kWh per capita in 1990, but fell to 36.51 kWh per capita in 2000, and further fell to 21.35 kWh per capita in 2009 (World Bank, 2012a). Inadequacy of electricity is obvious as only 13% of the population has access to electricity, thereby positioning the country not only below the average of Sub-Saharan Africa in general at 25%, but also behind its neighbours such as Ghana at 60% and Benin at 24.1% (REEEP, 2012). Within these periods, economic activity generally nosedived with the real GDP per capita at USD361.52 in 1980 and at USD281.83 in 2009, which makes Togo's growth rate among the weakest in Sub-Saharan Africa with per capita income declining by an average of 1% annually since the early 1980s (World Bank, 2012a). It is therefore pertinent to assess whether economic growth and electricity consumption are associated in Togo. More importantly, it is necessary to determine whether the country's poor growth is responsible for inadequate electricity availability or otherwise.

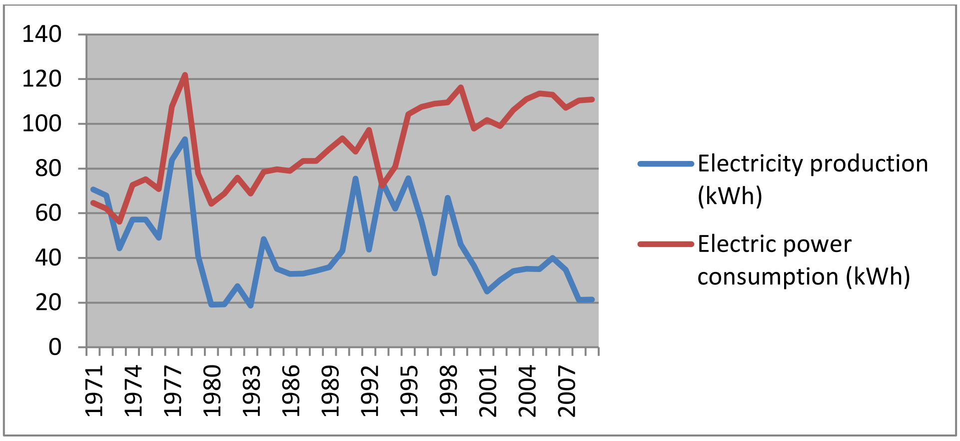

FIGURE 1 ELECTRICITY PRODUCTION AND CONSUMPTION IN TOGO, 1971-2009

The current study examines the existence of causation between electricity consumption and economic growth of Togo for the period 1971-2009. Distinct from the study of Alinsato (2009), who utilised a bivariate analysis, the current paper approach the study in a multivariate framework by including capital formation, export and urbanisation rate as control variables. This is done to elude biased results caused by omission of relevant variables in causality test (Asafu-Adjaye, 2000, Lutkepohl, 1982; Stern and Cleveland 2004). Beyond the statistical advantage of multivariate approach over bivariate framework, the selected control variables are actually pertinent in the case of the relationship between electricity consumption and economic growth in the country. For example, substantial portion of the available electricity is consumed in the urban centres. Roughly 80% of the peak demand for electricity, and the majority of total consumption occur in Lome (the capital city) and its environs. Moreover, the industrial and institutional sectors (chiefly concentrated in the urban centres) account for 31% and 15% of the country's total electricity consumption. The share of urbanisation population to the total population continues to grow as it was 5.302% in 1998 and 3.794% in 2009. Justifying the inclusion of export, the country is the fourth largest exporter of phosphate in the globe and a major exporter of cement. Two major companies in these sectors (International Fertilizer Group or IFG-Togo- and West African Cement Company or

WACEM) are among the five main customers of the Electricity Community of Benin (CEB's) (REEEP, 2012; World Bank, 2012a). Moreover, the importance of export to the economy is gaining momentum as export as a share GDP has generally increased over the years with the figure at 27.905% in 1971 and 37.836% in 2009 (United Nations, 2012). The inclusion of these variables will also enable the study to determine if the economy is actually urbanisation-led, capital-led and also export-led.

The rest of the paper is arranged as follows. Section 2 involves literature review pertaining to electricity consumption and economic growth. Section 3 provides a summary of electricity sector and the Togolese economy and Section 4 elucidates the methodology employed in this study. Section 5 shows the empirical results and the last section concludes the paper.

2. LITERATURE REVIEW

Electricity as a source of energy is vital to the economic expansion of many countries. Adequate electricity may boost output of firms through the improvement of labour and capital productivity (KouaKou, 2011). At macroeconomic level, economic progress requires changes in several segments of the economy including the electricity sector. In many countries, access to electricity is often used a yardsticks of evaluating governments' performances, especially in developing countries. Thus the importance of electricity in any economic setting can hardly be overemphasised. Correspondingly, a large part of the literature has examined electricity and growth link, even in the developing countries. Common among these enormous studies is the utilisation of causality methods to explore the relationship between electricity consumption and economic growth. However, studies differ in various respects, including the usage of bivariate or multivariate framework; and different time periods.

Within a bivariate framework, Altinay and Karagol (2005) examine the relationship between economic growth and electricity consumption in Turkey for the 1950-2000 period. The paper finds evidence for unidirectional causality from electricity consumption to economic growth. Tang (2008) probes the electricity-growth nexus in Malaysia for 1972:1 to 2003:4. The study fails to provide evidence for cointegration, but suggests bidirectional causality between electricity consumption and economic growth.

There are also bivariate studies for African countries. For example, Kouakou (2011) investigates the causal relationship between electric power and economic activities in Cote d'Ivoire from 1971 to 2008. The author observes bidirectional causality for electric power and economic activities in the short run, and unidirectional causality from electric power to economic activity in the long run. Besides, Odhiambo (2009a) explores the data of Tanzania for the period 1971-2006 to determine the nature of electricity-growth relationship in the country. Odhiambo (2009a) provides support for unidirectional causal flow from electricity consumption to economic growth, thereby concluding that Tanzania is an electricity dependent country. Using the data of Malawi for period 1970-1999, Jumbe (2004) provides evidence for feedback hypothesis in the country. Moreover, Akinlo (2009) investigates the causality relationship between electric power and economic growth for Nigeria, while utilising the data of 1980 to 2006. After establishing long run link, the results illustrate unidirectional causality flowing from electric power to economic growth in Nigeria.

Asafu-Adjaye (2000), Karanfil (2008), Lutkepohl (1982), and Stern and Cleveland (2004) highlight the enormity of the biasness caused by omission of important variables, which is more common in models with bivariate approach. According to Akinlo (2009) and Stern and Cleveland (2004), problems associated with omitted variables bias are ameliorated within multivariate framework. In the electricity-economic growth nexus, most recent papers have utilised multivariate framework. Lorde, Kimberly and Brain (2010) explore the causation in electric power and economic growth in the case of Barbados. Using data for 1960 to 2004, the study provides for variables such as capital stock, labour force and technology. The results support feedback hypothesis for Barbados. Yuan et al (2008) consider the relationship between electricity and economic growth for the case of China for the period covering 1963 to 2005. Controlling for capital and labour, the findings demonstrate unidirectional causality from electricity consumption to national income. Besides, Narayan and Singh (2007) probe the nexus for the case of Fiji within a multivariate framework that include labour force variable for the period 1971-2002. The findings reveal causation flowing from electricity consumption to GDP.

Halicioglu (2007) controls for urbanisation to support long run unidirectional causality from economic growth in Turkey, over the period 1968-2005. Acaravci and Qzturk (2012) revisit the electricity-growth nexus by incorporating employment as control variable in Turkey for 1968-2006 period. They provide support for unidirectional causality from electricity consumption to economic growth. Moreover, employing data from 1971 to 2006, Lean and Smyth (2010) consider the relationship between electricity and national output in Malaysia. Controlling for exports, labour and capital formation, the study observes bidirectional causality between electricity consumption and national output.

Recently, studies for African countries have also turned to the use of multivariate framework (especially trivariate approach) to investigate the connection between electricity consumption and economic growth. For example, Ouédraogo (2010) considers the nexus in the case of Burkina Faso and add capital formation to the system, for the period 1968-2003. The findings reveal the existence of short-run and the long run feedback hypothesis in Burkina Faso. In a trivariate study for another African country, Odhiambo (2009b) includes employment for South Africa for the period 1971 to 2006. The result supports feedback hypothesis in South Africa. For the case of Kenya, Odhiambo (2010) estimates the causation between electricity consumption and economic growth with labour participation as an intermediate variable during the period of 1972-2006. Solarin (2011) examines the electricity consumption and national output in Botswana with capital formation for the period covering 1980-2008. The author observes unidirectional causality from electricity consumption to national output. Solarin and Bello (2011) explore the electricity-growth nexus for Nigerian economy by incorporating capital and labour in production function for 1980-2008. The empirical evidence suggests unidirectional causation running from electricity consumption to economic growth in Nigeria, thereby validating growth hypothesis. In the same vein, Solarin and Shahbaz (2013) examine the causality between electricity consumption and economic growth in Angola, while urbanisation rate is added to system. The results indicate the existence of long run relationships. They further observe evidence in favour of bidirectional causality between electricity consumption and economic growth.

3. ELECTRICITY AND THE ECONOMY OF TOGO

Situated in the Gulf of Guinea, Togo is a West African country which borders Burkina Faso to the north, Benin to the east and Ghana to the west. Rich in natural resources; it is the world's fourth-largest producer of phosphate (UN FOUNDATION, 2012). It is a major cement exporting country (through WACEM), especially to fellow West African neighbours. Upon gaining independence from France in 1960, the government embarked on several infrastructural development programmes to develop the economy. For the case of electricity, Electricity Power Company of Togo (CEET) was established in March 20, 1963 with the objectives of ensuring adequate generation, transmission, distribution and sale of electric power in Togo. CEET generates electricity from thermal, hydropower installations and gas turbines. Another utility- Electricity Community of Benin (CEB) –completely owned by the governments of Benin and Togo- was established in 1968 to provide electricity in Benin and augment the services of CEET in Togo. Electricity supply in Togo is largely handled by CEB and CEET. The CEET buys electricity from the CEB (accounting for 90% of the total electricity at the disposal of CEET), and also generates its own electricity from diesel-powered thermal stations (which exist throughout Togo) and the Kpimé dam. Distribution in Togo is the duty of the CEET, which is single market player. However, in addition to these two firms, there are independent individuals and industries that generate their own electricity with the aid of generators (REEEP, 2012).

The electricity sector in Togo has continually experienced structural changes in order to thwart energy crisis. Due to increasing energy demand in the country, further link was established in bid to import electricity from Ghana in 1972. Since then, the process of importing electricity has remained. For example, in 1985, CEB purchased electric power from the Volta River Authority (VRA), the electricity company of Ghana, and sold it to the distribution companies and large consumers of Togo and Benin. To meet its requirements, CEB operated two 161 kV transmission lines from Ghana linked to a substation in Lome, from where the energy are transformed into lower voltages before delivery to customers (AFDB, 1999). In the year 1998, 350 million kWh worth of electricity was imported from Ghana to augment the local production of 90 million kWh, which could not meet the local consumption of 434 million kWh. Togo imported 500 million kWh and 486 million kWh worth of electricity from Ghana to partly meet the local demand of 602 million kWh and 576 million kWh consumed in the country for the years 2002 and 2005, respectively (Togo, 2007; UN FOUNDATION, 2012).

Beyond electricity supply augmentation, the government has further undertaken several steps to improve electricity supply in the country. For instance in 2000, following a reform of the electricity sector, distribution responsibilities of electric power in Togo was briefly outsourced. In 2009, the government contracted an international power company for the construction, design and operation of a fresh 100 megawatts (MW) power plant, which was projected to produce approximately 780 gigawatts (GW) hours of electricity annually, using natural gas supplied by the West Africa Gas Pipeline. The Togolese government further sought for technical assistance to develop an appropriate reform plan for CEET that would enable the company to entice strategic private partners for capital and investment (PPIAF, 2011).

In spite of all these efforts to improve electricity supply, challenges in electricity sector are still very enormous. Only 20% of the population had access to electricity in 2009. In the rural areas, the rate is 4% in comparison with more than 32% of Sub-Saharan average (AFDB, 2009; World Bank, 2012a). Globally, the country stands at 92 in the ranking of 183 economies on the ease of getting electricity (World Bank, 2012b). Getting new electricity connection in Togo requires four procedures which takes an average of 74 days and costs 6023.2% of income per capita. The average number of outages experienced by a firm in a month in 2009 was more than 11 times (World Bank, 2012b). Togo's distribution network has worsened from lack of investment and maintenance, causing severe voltage drops, use of unsafe equipment and high technical losses. The country's social and political tensions have limited the capacity to generate the necessary funding to encounter increasing electricity demand, and to adequately improve the distribution network (REEEP, 2012).

The lack of adequate energy infrastructure and largely unsatisfied demand for electricity continue to impede the national income (PPIAF, 2011). For example, national output shrinked by 8.716% in 1983 and 1.060% in 2005; and grew by a meagre 1.040% in 2009. Expectedly, 32% of the population were below poverty line in 2007. The economy recorded per capita income of US$260.720 in 2009, which is lower than the averages of Sub-Saharan Africa at US$629.883 and low income countries at US$340.687 (UN FOUNDATION, 2012; World Bank, 2012a).

4. METHODOLOGY

In order to examine the relationship between electricity and economic growth, while controlling for other variables in the case of Togo, the current study applies the following model;

$$GDP_t = f(ELE_t, CAP_t, EXP_t, URB_t) \quad (1)$$

Here, *GDP* is real gross domestic product per capita (2005=100), *ELE* is electric power consumption (kWh per capita), *CAP* is share of real gross fixed capital formation (2005=100) to real gross domestic product (2005=100), *EXP* is share of real exports of goods and services (2005=100) to real gross domestic product (2005=100) and *URB* is ratio of urban population to total population in Togo. Data for *GDP, ELE* and *URB* were extracted from *World Development Indicator* of the World Bank (World Bank, 2012a), while data for *CAP* and *EXP* were obtained from *United Nations Database* (United Nations, 2012). We focus on the period, 1971-2012, which has been selected based on availability of data. Besides, this phase captures most of the numerous developments in the electricity sector of Togo. The model is specified in a double-log form as all the variables are expressed in logarithmic form because it produces a better result compared to the linear functional form (Shahbaz and Lean, 2012). There are many contending variables to serve as control variables in electricity consumption and economic growth regression. However, capital, exports and urbanisation have been selected due to availability of data, relevance and also justification from previous studies.

Capital stock is a significant factor in the production function. Although the relationship between capital and energy is debatable, Ebohon (1996) argues that energy complements the role of capital in developing countries. Moreover, the inclusion of more variables such as capital incorporates more information that affects aggregate output than in the bivariate case, in which electricity alone is considered as the sole factor (Loizides and Vamvoukas, 2005). In the past, literature has controlled for capital formation in electricity-growth equation (see Lean and Smyth, 2010; Ouédraogo, 2010; Solarin, 2011; Solarin and Bello, 2011).

Inclusion of proxy for export development provides the opportunity of testing for the existence of the export-led hypothesis, which is validated with causality running from exports to GDP. The existence of export-led hypothesis may be attributed to the notion that export is essentially a component of GDP in national accounting or countries with a high export to GDP ratio are more open to outside influences and generate externalities, such as incentive to innovate (Lean and Smyth, 2010; Narayan and Smyth, 2009). Previous studies have included export (see Oderinde and Wakeel, 2011; Sami and Makun, 2011).

Urbanisation is a major feature of economic development, especially in the developing countries, where the pace of urbanisation is most significant. In developing countries, urbanisation triggers several structural shifts throughout the economy and has important implication to energy consumption. The increase in economic activities, resulting from urbanization causes the demand for energy (including electricity) consumption to rise (Liu, 2009; Solarin 2014a). Halicioglu (2007) and Holtedahl and Joutz (2004) argue that it is not only electricity consumption, but also urbanization that matters in the process of economic development. Shahbaz and Lean (2012) show that promoting urbanization is essential in the process of development. Few studies have included urbanization as one of the potential determinants of economic growth in an energy consumption-economic growth equation (see Halicioglu, 2007; Liu, 2009; Poumanyvong and Kaneko, 2010; Solarin and Shahbaz, 2013; Solarin, 2014b).

The traditional unit root tests such as ADF and PP may produce biased and inefficient results, if structural break(s) occur(s) in a time series. To avoid this problem, the current study applies the Lee and Strazicich (2003; 2004) tests (supplemented by Perron (1997) test) which provide for structural break(s). The Lee and Strazicicih (2003; 2004) are specified as follows:

$$\Delta S_t = \delta' \Delta Z_t + \phi \bar{S}_{t-1} + \sum_{i=1}^{p} \gamma \Delta \bar{S}_{t-i} + \mu_t \qquad \textbf{(2)}$$

Here, Δ is the difference operator, while $\bar{S}_{t-i}$ is the detrended value of S_{t-i}. The null of unit root, $\phi = 0$ is tested against the alternative hypothesis $\phi < 0$. Structural break is incorporated into the model with Z_t, which is a vector of exogenous variables. In a specification that allows for a single change in both level and trend, $Z_t = [1, t, D_{1t}, DT_{1t}]'$ where $DT_{1t} = t$ if $t \geq T_B + 1$, and 0, otherwise. D_{1t} and DT_{1t} are the dummy variables that denote the time when a structural break occurs in the level and trend respectively. To endogenously determine the location of $\lambda_j = T_{Bj} / T, j = 1$, the "minimum LM test" in Lee and Strazicich (2004) is used. In a specification that provides for two changes in both level and trend, $Z_t = [1, t, D_{1t}, D_{2t,} DT_{1t}, DT_{2t}]'$ where $DT_{jt} = t$ if $t \geq T_{Bj} + 1, j = 1, 2$ and 0, otherwise. Augmented terms of $\Delta\bar{S}_{t-i}$ are introduced to ensure there are no serial correlations in the errors[2].

In order to examine the long-run relationship between the variables, the present study utilizes ARDL approach to cointegration as advanced by Pesaran et al. (2001). Although there are several methods of cointegration tests, bound testing has several advantages. First, the procedure is applicable notwithstanding the variables are purely I(0), I(1) or mutually cointegrated. Second, it is not adversely affected by small sample data set. Third, the relationship in short-run and long-run can be estimated simultaneously. The unrestricted error correction model (UECM) below is used for the estimation.

$$\Delta GDP_t = \gamma_{10} + \gamma T_{11} + \sum_{i=1}^{p} \gamma_{12} \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_{13} \Delta ELE_{t-i} + \sum_{i=0}^{p} \gamma_{14} \Delta CAP_{t-i} + \sum_{i=0}^{p} \gamma_{15} \Delta EXP_{t-i}$$
$$+ \sum_{i=0}^{p} \gamma_{16} \Delta URB_{t-i} + \pi_1 GRO_{t-1} + \pi_2 ELE_{t-1} + \pi_3 CAP_{t-1} + \pi_4 EXP_{t-1} + \pi_5 URB_{t-1} + \varepsilon_{1t} \tag{3}$$

$$\Delta ELE_t = \gamma_{20} + \gamma T_{21} + \sum_{i=1}^{p} \gamma_{22} \Delta ELE_{t-i} + \sum_{i=0}^{p} \gamma_{23} \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_{24} \Delta CAP_{t-i} + \sum_{i=0}^{p} \gamma_{24} \Delta EXP_{t-i}$$
$$+ \sum_{i=0}^{p} \gamma_{25} \Delta URB_{t-i} + \pi_1 ELE_{t-1} + \pi_2 GDP_{t-1} + \pi_3 CAP_{t-1} + \pi_4 ELE_{t-1} + \pi_5 URB_{t-1} + \varepsilon_{2t} \tag{4}$$

$$\Delta CAP_t = \gamma_{30} + \gamma T_{31} + \sum_{i=1}^{p} \gamma_{32} \Delta CAP_{t-i} + \sum_{i=0}^{p} \gamma_{33} \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_{34} \Delta ELE_{t-i} + \sum_{i=0}^{p} \gamma_{35} \Delta EXP_{t-i}$$
$$+ \sum_{i=0}^{p} \gamma_{36} \Delta URB_{t-i} + \pi_1 CAP_{t-1} + \pi_2 GDP_{t-1} + \pi_3 ELE_{t-1} + \pi_4 EXP_{t-1} + \pi_5 URB_{t-1} + \varepsilon_{3t} \tag{5}$$

$$\Delta EXP_t = \gamma_{40} + \gamma T_{41} + \sum_{i=1}^{p} \gamma_{42} \Delta EXP_{t-i} + \sum_{i=0}^{p} \gamma_{43} \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_{44} \Delta ELE_{t-i} + \sum_{i=0}^{p} \gamma_{45} \Delta CAP_{t-i}$$
$$+ \sum_{i=0}^{p} \gamma_{46} \Delta URB_{t-i} + \pi_1 EXP_{t-1} + \pi_2 GDP_{t-1} + \pi_3 ELE_{t-1} + \pi_4 CAP_{t-1} + \pi_5 URB_{t-1} + \varepsilon_{4t} \tag{6}$$

[2] To determine the optimal lag length, we adopt the procedure suggested by Ng and Perron (1995).

$$\Delta URB_t = \gamma_{50} + \gamma T_{51} + \sum_{i=1}^{p} \gamma_{52} \Delta URB_{t-i} + \sum_{i=0}^{p} \gamma_{53} \Delta GDP_{t-i} + \sum_{i=0}^{p} \gamma_{54} \Delta ELE_{t-i} + \sum_{i=0}^{p} \gamma_{55} \Delta CAP_{t-i}$$
$$+ \sum_{i=0}^{p} \gamma_{56} \Delta EXP_{t-i} + \pi_1 URB_{t-1} + \pi_2 GDP_{t-1} + \pi_3 ELE_{t-1} + \pi_4 CAP_{t-1} + \pi_5 EXP_{t-1} + \varepsilon_{5t} \quad \textbf{(7)}$$

Here Δ is the difference operator, *ln* denotes the natural logarithm and *p* is the lag length. The residuals ε_{it} are assumed to fulfil the classical assumption of normal distribution and white noise. In line with Pesaran et al. (2001), F-test is utilised to determine the existence of long-run relationship, which is true when alternate hypothesis of cointegration $(H_a : \pi_1 \neq \pi_2 \neq \pi_3 \neq \pi_4 \neq \pi_5 \neq 0)$ is established. Conversely, if the null of no cointegration $(H_0 : \pi_1 = \pi_2 = \pi_3 = \pi_4 = \pi_5 = 0)$ is true, then there is no long run relationship in the series. Further, Pesaran et al. (2001) construct two set of asymptotic critical values for ARDL cointegration test, popularly called lower bounds critical values for $I(0)$ and upper bounds critical values for $I(1)$. Nevertheless, critical values proposed in Pesaran et al. (2001) are not suitable for finite sample study. Narayan (2005) produced a new set of critical values for small sample, which is a feature of the current study (with 39 observations). Hence, this paper implements critical values of Narayan (2005). According to the bound testing procedure, if the calculated F-statistics is lower than the lower bound critical value, then null hypothesis is accepted, indicating non-existence of cointegration. If the computed F-statistic is higher than the upper bound critical value, the null hypothesis is rejected, signifying cointegration. However, if the calculated F-statistic falls between the two critical bounds, inference would be inconclusive.

Granger causality involves the usage of past values of a variable to possibly predict changes in another variable. According to the causality test, X causes Y' if and only if the past values of X help to predict the changes of Y. On the other hand, 'Y causes X' if and only if the past values of Y help to predict the changes of X. The vector autoregression (VAR) model is routinely employed for the purpose of testing for the presence of Granger causality. However, the standard first difference VAR model becomes inappropriate, if a set of variables are cointegrated (Granger, 1988). In such case, Granger causality test must be implemented within VECM framework as follows:

$$(1-L)\begin{bmatrix} \ln GDP_t \\ \ln ELE_t \\ \ln CAP_t \\ \ln EXP_t \\ \ln URB_t \end{bmatrix} = \begin{bmatrix} \beta_1 \\ \beta_2 \\ \beta_3 \\ \beta_4 \\ \beta_5 \end{bmatrix} + \sum_{i=1}^{p}(1-L)\begin{bmatrix} B_{11i}B_{12i}B_{13i}B_{14i}B_{15i} \\ B_{21i}B_{22i}B_{23i}B_{24i}B_{25i} \\ B_{31i}B_{32i}B_{33i}B_{34i}B_{35i} \\ B_{41i}B_{42i}B_{43i}B_{44i}B_{45i} \\ B_{51i}B_{52i}B_{53i}B_{54i}B_{55i} \end{bmatrix} \times \begin{bmatrix} \ln GDP_{t-i} \\ \ln ELE_{t-i} \\ \ln CAP_{t-i} \\ \ln EXP_{t-i} \\ \ln URB_{t-i} \end{bmatrix} + \begin{bmatrix} \alpha_1 \\ \alpha_2 \\ \alpha_3 \\ \alpha_4 \\ \alpha_5 \end{bmatrix} ECT_{t-1} + \begin{bmatrix} \varepsilon_{1t} \\ \varepsilon_{2t} \\ \varepsilon_{3t} \\ \varepsilon_{4t} \\ \varepsilon_{5t} \end{bmatrix} \quad \textbf{(8)}$$

where $\ln$ is the natural logarithm and $(1-L)$ is the difference operator. The residuals ε_{it} are assumed to fulfil the classical assumption of normal distribution and white noise. ECT_{t-1} (lagged error correction term computed from the cointegration equation) is excluded from the regression(s), if cointegration does not exist among the variables. The significance of t-test on ECT_{t-1} (if applicable) indicates the incidence of long run causal relations in the series. Short run causality is established by applying F-test on the lagged terms of each series. For instance, *ELE* Granger causes *GDP* if $B_{12,i} \neq 0 \forall_i$ while $B_{21,i} \neq 0 \forall_i$ imply *GDP* does not lead *ELE* in the short run.

5. RESULTS AND DISCUSSION

The estimates of ARDL bound testing becomes unreliable if any of the series is I(2) or above, which makes it necessary to ensure the variables under consideration are either I(0) or I(1) (Solarin and Dahalan, 2011). In this section, the results of Lee and Strazicich (2003; 2004) unit root tests are reported. For robustness sake, the study also includes the outputs of another unit root test, Perron (1997), from which the analysis starts[3]. In Panel-A of Table-1, the findings of Perron (1997) unit root test are reported. At level, the null of unit root cannot be rejected for any of the variables. At first difference, the null of unit root can be rejected for all the variables at 1% level, with the exception of *lnY,* which can be rejected at 5% level. Proceeding with the findings of Lee and Strazicich (2004) unit root test, the results indicate that null of unit root cannot be rejected for any of the variables, when at level. At first difference, the null of unit root can be rejected for all the variables, with *lnCAP* and *lnURB* at 5% level. The powers of the preceding unit root tests are weakened in cases of more than a break in the series. Results of Lee and Strazicich (2003) double breaks are reported in Panel-B of Table-1. It is observed that none of the series is stationary at level. However, at first difference the null of unit root can be rejected for all the variables. In summary, this is evidence that the series are stationary at first difference. Almost 33% of the break dates coincided with the period of 1974-1979, which was characterised by various international shocks (oil shocks and commodity booms), bad macroeconomic policies and unsustainable growth that affected the country. These include the oil shocks of 1973 and 1975 that surprised the country and caused growth rate of GDP to fall steeply. Second, the phosphate boom of 1974 and 1975, and the 1977 upsurge in price of coffee, triggered a reverse outcome (Gogué and Evlo, 2005)

Given that all variables are I(1), the study proceeds to examine whether the variables are cointegrated with the use of bounds test in Table-2. There is evidence of cointegration, when *lnY* is the dependent variable because F-statistic (5.312) is greater than the upper bounds critical value (4.587) at 5% significant level. The same inference cannot be made, when other variables are assigned as the dependent variables because their F-statistic (2.987, 2.334, 1.487, and 0.523) is less than the upper bounds critical value (3.918) at 10% significant level. In order to ensure robustness of the estimates, a set of diagnostic tests are conducted on the selected ARDL models. Breusch-Godfrey LM test cannot reject the null hypothesis of no autocorrelation, suggesting absence of serial correction in the ARDL models. The autoregressive conditional heteroscedasticity (ARCH) tests show the ARDL specification is homoscedastic

[3] See Lee and Strazicich (2001) for the virtues of Lee and Strazicich (2003; 2004) procedures.

and the Jarque-Bera normality tests demonstrate the null hypothesis of normal distribution cannot be rejected. Similar to the traditional unit root tests, the outcome of ARDL becomes less reliable with the occurrence of structural break. To address this problem, the study reports Gregory and Hansen (1996) cointegration test in Table-3. Fortunately, all the series are I(1), a requirement of Gregory and Hansen (1996) test. Using the Augment –Dickey Fuller (ADF) variant of the test, there is evidence of cointegration, when *lnY* is the dependent variable. However, when other variables are the dependent variables, there is no existence of cointegration, which does not only confirm the earlier findings of ARDL approach, but also the study of Solarin (2011) for the case of Botswana.

At this stage, it is appropriate to perform the Granger causality test, which may help policymaking in energy and economic discourse. Single cointegration relationship established with ARDL bound test illustrates the presence of Granger causality in at least one path, but does not identify the direction of causality in the series. The results of Granger causality, within the VECM framework are presented in Table-4. Commencing with short run causality test, the estimates show *lnEC* to Granger cause *lnY* at 10% level*,* with no response from *lnY* to *lnEC*. Further, there is causation from *lnY* and *lnCAP* to *lnURB,* with no feedback from *lnURB*. In the long run, there is unidirectional causality flowing from *lnEC* to *lnY*. Similar to the short run outcomes, this is supporting growth (or electricity-led) hypothesis in the economy, which implies that expansive energy policies are necessary for sustainable economic growth. Previous studies with similar observations are Odhiambo (2010) and Solarin and Bello (2011) for the case of Kenya and Nigeria, which are fellow African countries; Narayan and Singh (2007) for Fiji; and Yuan et al. (2008) for China. Besides, long run causality results points to the existence unidirectional causation from all the other variables towards *lnY*. This is an evidence for capital-led, export-led and urbanisation-led economy in the country. The findings on capital-led is lined with Solarin (2011), while observation on export-led is lined with the Lean and Smyth (2010) for Malaysia. Collectively, these suggest expansive energy policies may not be enough to lift the country out of its recent economic stagnation, without corresponding policies such as export development, accelerated capital formation and checking the pace of urbanisation.

Since causality test does not signify whether regressors will positively or negatively affect the dependent variables, the study reports coefficients of ARDL, FMOLS (fully modified OLS), (Dynamic OLS) DOLS in Table-5. Generally, *lnEC* indicates long run positive effect on the *lnY*, thus substantiating the validity of energy expansionary policies for the case of Togo. The results also show that while changes in *lnEC* and *lnEXP* positively affect *lnY*, *lnURB* negatively influence *lnY* in the long run. Therefore, electricity alone is insufficient to promote economic growth in Togo; it must be complemented with other factors such as development of the export industry; improvement of capital formation (probably through savings); and taming the pace of urbanisation.

Table-1: Unit root test

	PANEL A: PERRON (1997) AND LEE AND STRAZICICH (2004)											
	PERRON (1997)						LEE AND STRAZICICH (2004)					
	LEVEL			1ST DIFF.			LEVEL			1ST DIFF.		
VARIABLE	T-STAT	BREAK	Λ	T-STAT	BREAK	Λ	T-STAT	BREAK	Λ	T-STAT	BREAK	Λ
$\ln Y_t$	-4.041[0]	1993	0.6	-5.973**[3]	1993	0.6	-3.143[1]	1982	0.4	-6.329***[0]	1984	0.4
$\ln EC_t$	-4.670	1979	0.2	-7.401***[0]	1979	0.2	-4.140[0]	1979	0.2	-6.894***[1]	1980	0.2
$\ln CAP_t$	-3.498[0]	1989	0.5	-8.921***[0]	1993	0.6	-3.905[3]	1990	0.6	-4.925**[3]	1997	0.8
$\ln EXP_t$	-5.086[0]	1989	0.5	-9.833***[0]	1993	0.6	-3.430[2]	1990	0.6	-6.495***[1]	1986	0.4
$\ln URB_t$	-3.516[1]	2000	0.8	-8.197***[0]	1980	0.2	-2.422[1]	1985	0.4	-4.567**[1]	1986	0.4

	PANEL-B: LEE AND STRAZICICH (2003)							
	LEVEL				1ST DIFF.			
	T-STAT	BREAK (1)	BREAK (2)	Λ1 Λ2	T-STAT	BREAK (1)	BREAK (2)	Λ1 Λ2

$\ln Y_t$	-4.535[1]	1979	1996	(0.2, 0.6)	-5.895**[1]	1992	1998	(0.6, 0.8)
$\ln EC_t$	-4.230[2]	1982	1994	(0.4, 0.6)	-8.543***[0]	1977	1980	(0.2, 0.4)
$\ln CAP_t$	-4.429[1]	1975	1993	(0.2, 0.6)	-8.910***[0]	1977	1994	(0.2, 0.6)
$\ln EXP_t$	-4.978[3]	1982	1993	(0.4, 0.6)	-9.604***[0]	1985	2004	(0.4, 0.8)
$\ln URB_t$	-3.479[1]	1979	1996	(0.2, 0.6)	-8.610***[2]	1979	1985	(0.2, 0.4)

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 LENGTH IS SET AT 3. CRITICAL VALUES FOR PERRON TEST, OBTAINED FROM PERRON (1997) ARE 5.29, -5.59 AND -6.32 FOR 10%, 5% AND 1% LEVELS, WHILE CRITICAL VALUES FOR LEE AND STARZICICH ONE BREAK TESTS OBTAINED FROM LEE AND STARZICICH (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.

Table-2: ARDL bound test

BOUNDS TEST			DIAGNOSTIC TESTS		
DEPENDENT VARIABLE	F-STATISTIC	OPTIMAL LAG	χ^2_{SERIAL}	χ^2_{ARCH}	χ^2_{NORMAL}
$\ln Y_t$	5.312**	(1, 2, 0, 0, 0)	0.877[1]	0.109[1]	1.268[2]
$\ln EC_t$	2.987	(3, 0, 0, 0, 0)	0.296[1]	0.979[1]	0.442[2]
$\ln CAP_t$	2.334	(1, 0, 0, 0, 0)	0.110[1]	0.864[1]	0.315[2]
$\ln EXP_t$	1.487	(0, 0, 3, 0, 1)	0.235[1]	0.694[1]	0.107[2]
$\ln URB_t$	0.523	(3, 3, 2, 2, 2)	0.634[1]	0.497[1]	0.126[2]

CRITICAL VALUES	10%I(0)	10%I(1)	5%I(0)	5%I(1)	1%I(0)	1%I(1)
NARAYAN (2005)	2.985	3.918	3.512	4.587	4.763	6.200

NOTE: ** DENOTE LEVEL OF SIGNIFICANCE AT 5%. CRITICAL VALUES ARE FOR MODEL WITH UNRESTRICTED INTERCEPT AND RESTRICTED TREND. OPTIMAL LAG LENGTH IS SET AT 3. P-VALUES ARE STATED FOR DIAGNOSTICS TESTS, WITH [ ] DEPICTING ORDER OF DIAGNOSTIC TESTS.

Table-3: Gregory-Hansen cointegration test

	MODEL			
DEPENDENT VARIABLE	LEVEL SHIFT		LEVEL SHIFT WITH TREND	
	T-STAT	BREAK	T-STAT	BREAK
$\ln Y_t$	-5.748**[3]	1989	-5.841**[3]	1983
$\ln EC_t$	-4.042[3]	1975	-4.138[3]	1979
$\ln CAP_t$	-3.085[3]	1984	-4.021[3]	1975
$\ln EXP_t$	-3.641[0]	1984	-3.560[0]	1986
$\ln URB_t$	-2.574[0]	2001	-2.987[3]	1982

NOTE: ** DENOTE LEVEL OF SIGNIFICANCE AT 5%. OPTIMAL LAG LENGTH IS SET AT 3. THE CRITICAL VALUE FOR THE MODEL WITH LEVEL SHIFT ARE -5.31, - 5.56 AND -6.05 AND FOR LEVEL SHIFT WITH TREND MODEL ARE – 5.59, - 5.83 AND - 6.36 AT 10%, 5% AND 1% LEVELS, RESPECTIVELY [] IS OPTIMAL LAG

Table-4: Granger causality test

Dependent Variable	Direction of Causality					
	Short Run					Long Run
	$\Delta \ln Y_{t-i}$	$\Delta \ln EC_{t-i}$	$\Delta \ln CAP_{t-i}$	$\Delta \ln EXP_{t-i}$	$\Delta \ln URB_{t-i}$	ECT_{t-1}
$\Delta \ln Y_t$	….	3.267*	0.043	0.410	1.178	-1.748*
$\Delta \ln EC_t$	0.059	….	0.559	1.043	0.292	
$\Delta \ln CAP_t$	0.420	1.638	….	1.182	1.393	
$\Delta \ln EXP_t$	0.111	1.529	0.097	….	1.347	
$\Delta \ln URB_t$	8.322***	2.027	4.114*	0.810	….	

Note: *, ** and *** show significance at 10, 5 and 1% levels respectively.

TABLE-5: LONG-RUN AND SHORT RUN-COEFFICIENT

PANEL A: LONG RUN												
DEPENDENT VARIABLE	$\ln Y_t$											
	ARDL				FMOLS				DOLS			
	$\ln EC_t$	$\ln CAP_t$	$\ln EXP_t$	$\ln URB_t$	$\ln EC_t$	$\ln CAP_t$	$\ln EXP_t$	$\ln URB_t$	$\ln EC_t$	$\ln CAP_t$	$\ln EXP_t$	$\ln URB_t$
	0.573***	0.336	0.214*	-0.663***	0.161***	0.057*	0.112**	-0.353***	0.141	0.079*	0.091	-0.293**
PANEL B: SHORT RUN ELASTICITIES												
DEPENDENT VARIABLE	$\Delta \ln Y_t$											
	$\ln \Delta EC_t$		$\ln CAP_t$		$\ln EXP_t$				$\ln \Delta URB_t$			
	0.253***		0.020		0.128**				-0.397**			
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-SET AT 3- IS BASED ON BARTLETT WEIGHTS. AS REQUIRED, WE APPLY NEWEY-WEST ON THE ESTIMATES OF DOLS.												

Table-6: Forecasts of electricity gap, 1999–2020[4]

	Electricity Production (kWh per capita)		Electricity Consumption (kWh per capita)		Electricity Gap (kWh per capita)
Year	Actual	Forecast	Actual	Forecast	Gap
1999	46.014		116.325		-70.311
2000	36.508		97.841		-61.333
2001	24.969		101.702		-76.733
2002	30.094		98.992		-68.898
2003	34.041		106.184		-72.143
2004	35.172		111.000		-75.828
2005	34.948		113.535		-78.587
2006	39.965		113.022		-73.057
2007	34.673		107.203		-72.530
2008	21.292		110.441		-89.149
2009	21.349		110.813		-89.463
2010		21.426		108.767	-87.341
2011		19.817		108.835	-89.018
2012		18.208		108.903	-90.695
2013		16.599		108.971	-92.372
2014		14.990		109.039	-94.049
2015		13.381		109.107	-95.726
2016		11.772		109.175	-97.403
2017		10.163		109.243	-99.080
2018		8.554		109.311	-100.756
2019		6.945		109.379	-102.433
2020		5.336		109.447	-104.110

The alpha value for the forecast of electricity production is 0.015 and for the forecast of electricity consumption is 0.096. These figures do not only fall within the recommended range of Bowerman and O'Connell (1979), but also less than benchmark value of 0.5. In theory, the forecast is adequate because the lower the value of alpha, the less responsive the forecast is to sudden change.

Using the exponential smoothing method, the current study examines whether Togo's electricity insufficiency will ameliorate in the near future, given the current conditions. Exponential smoothing method is a very popular scheme to produce smoothed and forecasted time series (Pyo and Choi, 2009). Forecasting is very pertinent at this point as it has been highlighted in the foregoing analysis that expansionary electricity policies are necessary in the economy. If the electricity problem is likely to cease based on the current (and possibly expansionary) electricity policies, therefore there may not be any need for additional expansionary policies in the near future and vice versa. In Table-6, the findings on the forecast of electricity production per capita and the

[4] The exponential smoothing technique is based on single parameter (double) technique. This method involves a single smoothing method (using the same parameter) on the level and trend components of the variable and is appropriate for series with a linear trend (see Bowerman and O'Connell, 1979).

corresponding electricity consumption per capita for the period of 2010 and 2020 are reported. The statistics shows that electricity insufficiency will not only continue in the future, but in fact exacerbate. ELECTRCITY Gap will increase from 92.372 kWh per capita in 2013 to 97.403 kWh per capita and further to 104.11 kWh per capita in 2020. This indicates that accelerated expansionary policies are indeed needed in Togo, not only to meet electricity need of the country but also stimulate economic growth.

6. CONCLUSION

Togo is a country confronted with the challenges of inadequate electricity and virtual economic stagnation. Hence, this paper tests whether electricity (using electricity consumption) and economic activities are related, so that policies for the electricity sector may be recommended, which may serve as one of the means to overcome economic stagnation in the country. Adopting a multivariate approach that adds capital formation, export and urbanisation to the system, ARDL (with Gregory and Hansen test, FMOLS and DOLS as complements) is utilised to ascertain the long run relationship and Granger causality to investigate the flow of causation in the series. The findings identify long run relationship and indicate that while urbanisation impedes economic growth, electricity consumption, capital formation and export promotes economic activities. According to Granger causality tests, unidirectional causality flows from electricity consumption, capital formation, export, and urbanisation to economic progression in the long run.

In particular, the unidirectional causality running from electricity consumption to the economy implies that expansive energy policies are necessary for sustainable economic growth. In other words, one of the factors responsible for economic stagnation in the country is epileptic power supply. Lifting the economy out of its current sorry state will require policies to improve availability of electricity. As a country endowed with water bodies; Togo should expand its hydropower capabilities for electricity production. Constructing hydropower installations linked to rivers of Mono and Oti are highly encouraged as this effort alone offers a potential overall production capacity of 224 MW of electric power. Solar energy is another viable source of electricity in the country. Gifted with an average solar radiation of 4.4 and 4.5 kWh/m^2/day, there is the need to promote utilisation of solar energy, which will not only serve as a source of electricity but also act as a standalone complement to electricity production (REEEP, 2012).

However, increasing the availability of electricity alone may not lift the country out of its doldrums. Programmes designed to encourage export development; increase capital formation and check the trend of urbanisation are needed to complement electricity availability. These policies may not only directly influence economic growth, but also instigate economic growth through the development of the energy sector. For example, improved capital formation generates new investments, which are essential in expanding the current electricity distribution network in the country. One of the policies at the disposal of the government to discourage urbanisation is rural electrification. By improving availability of electricity in the rural areas, this may encourage companies (including exporting firms) to locate their operations in the rural areas.

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